SMITHSONIAN

CONTRIBUTIONS TO KNOWLEDGE.

VOL. II.

EVERY MAN IS A VALUABLE MEMBER OF SOCIETY, WHO, BY HIS OBSERVATIONS, RESEARCHES, AND EXPERIMENTS, PROCURES KNOWLEDGE FOR MEN.—SMITHSON.

CITY OF WASHINGTON:
PUBLISHED BY THE SMITHSONIAN INSTITUTION.
MDCCCLI.

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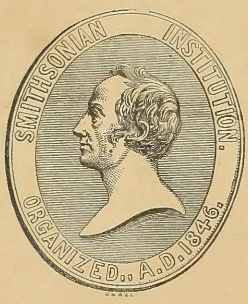

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ADVERTISEMENT.

This volume forms the second of a series, composed of original memoirs on different branches of knowledge, published at the expense, and under the direction, of the Smithsonian Institution. The publication of this series forms part of a general plan adopted for carrying into effect the benevolent intentions of JAMES SMITHSON, Esq., of England. This gentleman left his property in trust to the United States of America, to found at Washington an institution which should bear his own name, and have for its objects the "*increase* and *diffusion* of knowledge among men." This trust was accepted by the Government of the United States, and an Act of Congress was passed August 10th, 1846, constituting the President and the other principal executive officers of the general government, the Chief Justice of the Supreme Court, the Mayor of Washington, and such other persons as they might elect honorary members, an establishment, under the name of the "SMITHSONIAN INSTITUTION, FOR THE INCREASE AND DIFFUSION OF KNOWLEDGE AMONG MEN." The members and honorary members of this establishment are to hold stated and special meetings for the supervision of the affairs of the Institution, and for the advice and instruction of a Board of Regents, to whom the financial and other affairs are entrusted.

The Board of Regents consists of three members ex officio of the establishment, namely, the Vice President of the United States, the Chief Justice of the Supreme Court, and the Mayor of Washington, together with twelve other members, three of whom are appointed by the Senate from its own body, three by the House of Representatives from its members, and six citizens appointed by a joint resolution of both houses. To this board is given the power of electing a Secretary and other officers, for conducting the active operations of the Institution.

To carry into effect the purposes of the testator, the plan of organization should evidently embrace two objects,—one, the increase of knowledge by the addition of new truths to the existing stock; the other, the diffusion of knowledge, thus increased, among men. No restriction is made in favor of any kind of knowledge, and hence each branch is entitled to and should receive a share of attention.

The Act of Congress, establishing the Institution, directs, as a part of the plan of organization, the formation of a Library, a Museum, and a Gallery of Art, together with provisions for physical research and popular lectures, while it leaves to the Regents the power of adopting such other parts of an organization as they may deem best suited to promote the objects of the bequest.

After much deliberation, the Regents resolved to divide the annual income into two equal parts,—one part to be devoted to the increase and diffusion of knowledge by means of original research and publications,—the other half of the income to be applied, in accordance with the requirements of the Act of Congress, to the gradual formation of a Library, a Museum, and a Gallery of Art.

The following are the details of the two parts of the general plan of organization provisionally adopted at the meeting of the Regents, Dec. 8th, 1847.

DETAILS OF THE FIRST PART OF THE PLAN.

I. To increase Knowledge.—*It is proposed to stimulate research, by offering rewards for original memoirs on all subjects of investigation.*

1. The memoirs thus obtained to be published in a series of volumes, in a quarto form, and entitled "Smithsonian Contributions to Knowledge."

2. No memoir, on subjects of physical science, to be accepted for publication, which does not furnish a positive addition to human knowledge, resting on original research; and all unverified speculations to be rejected.

3. Each memoir presented to the Institution, to be submitted for examination to a commission of persons of reputation for learning in the branch to which the memoir pertains; and to be accepted for publication only in case the report of this commission is favorable.

4. The commission to be chosen by the officers of the Institution, and the name of the author, as far as practicable, concealed, unless a favorable decision be made.

5. The volumes of the memoirs to be exchanged for the Transactions of literary and scientific societies, and copies to be given to all the colleges, and principal libraries, in this country. One part of the remaining copies may be offered for sale; and the other carefully preserved, to form complete sets of the work, to supply the demand from new institutions.

6. An abstract, or popular account, of the contents of these memoirs to be given to the public, through the annual report of the Regents to Congress.

II. TO INCREASE KNOWLEDGE.—*It is also proposed to appropriate a portion of the income, annually, to special objects of research, under the direction of suitable persons.*

1. The objects, and the amount appropriated, to be recommended by counsellors of the Institution.

2. Appropriations in different years to different objects; so that in course of time, each branch of knowledge may receive a share.

3. The results obtained from these appropriations to be published, with the memoirs before mentioned, in the volumes of the Smithsonian Contributions to Knowledge.

4. Examples of objects for which appropriations may be made:

(1.) System of extended meteorological observations for solving the problem of American storms.

(2.) Explorations in descriptive natural history, and geological, mathematical, and topographical surveys, to collect materials for the formation of a Physical Atlas of the United States.

(3.) Solution of experimental problems, such as a new determination of the weight of the earth, of the velocity of electricity, and of light; chemical analyses of soils and plants; collection and publication of articles of science, accumulated in the offices of Government.

(4.) Institution of statistical inquiries with reference to physical, moral, and political subjects.

(5.) Historical researches, and accurate surveys of places celebrated in American history.

(6.) Ethnological researches, particularly with reference to the different races of men in North America; also explorations, and accurate surveys, of the mounds and other remains of the ancient people of our country.

I. TO DIFFUSE KNOWLEDGE.—*It is proposed to publish a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge not strictly professional.*

1. Some of these reports may be published annually, others at longer intervals, as the income of the Institution or the changes in the branches of knowledge may indicate.

2. The reports are to be prepared by collaborators, eminent in the different branches of knowledge.

3. Each collaborator to be furnished with the journals and publications, domestic and foreign, necessary to the compilation of his report; to be paid a certain sum for his labors, and to be named on the title-page of the report.

4. The reports to be published in separate parts, so that persons interested in a particular branch, can procure the parts relating to it without purchasing the whole.

5. These reports may be presented to Congress, for partial distribution, the remaining copies to be given to literary and scientific institutions, and sold to individuals for a moderate price.

The following are some of the subjects which may be embraced in the reports:

I. PHYSICAL CLASS.

1. Physics, including astronomy, natural philosophy, chemistry, and meteorology.
2. Natural history, including botany, zoology, geology, &c.
3. Agriculture.
4. Application of science to arts.

II. MORAL AND POLITICAL CLASS.

5. Ethnology, including particular history, comparative philology, antiquities, &c.
6. Statistics and political economy.
7. Mental and moral philosophy.
8. A survey of the political events of the world; penal reform, &c.

III. LITERATURE AND THE FINE ARTS.

9. Modern literature.
10. The fine arts, and their application to the useful arts.
11. Bibliography.
12. Obituary notices of distinguished individuals.

II. TO DIFFUSE KNOWLEDGE.—*It is proposed to publish occasionally separate treatises on subjects of general interest.*

1. These treatises may occasionally consist of valuable memoirs translated from foreign languages, or of articles prepared under the direction of the Institution, or procured by offering premiums for the best exposition of a given subject.

2. The treatises to be submitted to a commission of competent judges, previous to their publication.

DETAILS OF THE SECOND PART OF THE PLAN OF ORGANIZATION.

This part contemplates the formation of a Library, a Museum, and a Gallery of Art.

1. To carry out the plan before described, a library will be required, consisting, 1st, of a complete collection of the transactions and proceedings of all the learned societies in the world; 2d, of the more important current periodical publications, and other works necessary in preparing the periodical reports.

2. The Institution should make special collections, particularly of objects to verify its own publications. Also a collection of instruments of research in all branches of experimental science.

3. With reference to the collection of books, other than those mentioned above, catalogues of all the different libraries in the United States should be procured, in order that the valuable books first purchased may be such as are not to be found elsewhere in the United States.

4. Also catalogues of memoirs, and of books in foreign libraries, and other materials, should be collected, for rendering the Institution a centre of bibliographical knowledge, whence the student may be directed to any work which he may require.

5. It is believed that the collections in natural history will increase by donation, as rapidly as the income of the Institution can make provision for their reception, and, therefore, it will seldom be necessary to purchase any article of this kind.

6. Attempts should be made to procure for the gallery of art, casts of the most celebrated articles of ancient and modern sculpture.

7. The arts may be encouraged, by providing a room, free of expense, for the exhibition of the objects of the Art-Union and other similar societies.

8. A small appropriation should annually be made for models of antiquity, such as those of the remains of ancient temples, &c.

9. The Secretary and his assistants, during the session of Congress, will be required to illustrate new discoveries in science, and to exhibit new objects of art; distinguished individuals should also be invited to give lectures on subjects of general interest.

In accordance with the rules adopted in the programme of organization, each memoir in this volume has been favorably reported on by a commission appointed

for its examination. It is however impossible, in most cases, to verify the statements of an author, and therefore neither the Commission nor the Institution can be responsible for more than the general character of a memoir.

The following rules have been adopted for the distribution of the quarto volumes of the Smithsonian Contributions.

1. They are to be presented to all learned societies which publish Transactions, and give copies of these, in exchange, to the Institution.

2. Also, to all foreign libraries of the first class, provided they give in exchange their catalogues or other publications, or an equivalent from their duplicate volumes.

3. To all the colleges in actual operation in this country, provided they furnish, in return, meteorological observations, catalogues of their libraries and of their students, and all other publications issued by them relative to their organization and history.

4. To all States and Territories, provided there be given, in return, copies of all documents published under their authority.

5. To all incorporated public libraries in this country not included in either of the foregoing classes, now containing more than 7000 volumes; and to smaller libraries, where a whole State or large district would be otherwise unsupplied.

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(* Deceased.)

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* Each article is paged separately.

APPENDIX.

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

RESEARCHES

RELATIVE TO THE

PLANET NEPTUNE.

BY SEARS C. WALKER.

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TO WHICH THIS MEMOIR HAS BEEN REFERRED.

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RESEARCHES

RELATIVE TO

THE PLANET NEPTUNE.

The Memoir which I have the honor to present to the Smithsonian Institution relative to the planet Neptune, is divided into four sections, as follows:

SECTION 1.

ABSTRACT OF EVENTS CONNECTED WITH THE DISCOVERY OF NEPTUNE, THE PROGRESS MADE IN ITS THEORY, AND THE COMPLETION OF THE THEORY OF URANUS.

SECTION 2.

DETAILED ACCOUNT OF THE DISCOVERY OF THE TWO ANCIENT PLACES OF NEPTUNE, OBSERVED BY LALANDE IN MAY, 1795.

SECTION 3.

COMPUTATIONS CONFIRMING THE AUTHENTICITY OF LALANDE'S PRINTED OBSERVATIONS.

SECTION 4.

SUBSEQUENT RESEARCHES ON THE ORBIT OF NEPTUNE.

In this inquiry, it has been necessary to compute an Ephemeris of the planet for every day in which Neptune has been visible, and to compare with it nearly all the observations extant. Since it is desirable to make this group of observations, properly reduced, a matter of permanent record, this Ephemeris* is also respectfully submitted, together with the differences from it indicated by the standard observations.

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*For the sake of the more prompt appearance of this Ephemeris, it was published in advance of the Memoir, and separately distributed, in 1849. See Appendix, No. I, to this volume.—*Sec. Smithsonian Institution.*

SECTION 1.

ABSTRACT OF EVENTS CONNECTED WITH THE DISCOVERY OF NEPTUNE, THE PROGRESS MADE IN ITS THEORY, AND THE COMPLETION OF THE THEORY OF URANUS.

No. 1. The detection of the anomalies of Uranus, and the suggestion of an undiscovered planet as their probable cause, by Alexis Bouvard, in 1821. In his preface, he remarks:

"Je laisse au temps à venir le soin de faire connaitre, si la difficulté de concilier les deux *systêmes tient réellement à l'inexactitude des observations anciennes, ou si elle depend de quelque action étrangère et inapperçue, qui aurait agit sur la planète."

No. 2. The correction of certain points in Bouvard's theory of Uranus. The confirmation of the existence of these anomalies. The ascription of them to their true cause, viz., a single transuranian planet, by Bessel, in the years from 1821 to 1840.

No. 3. Bouvard's correspondence with Hansen on the subject of a transuranian planet; the opinion of Hansen that "one body would not satisfy the phenomena;" and his conjecture "that there were two planets beyond Uranus."

No. 4. Letter of Rev. T. J. Hussey to Prof. Airy, Nov. 17, 1834, proposing a search for the transuranian planet.

No. 5. Answer of Prof. Airy, Nov. 21: "The observations would be well reconciled, if we could from theory bring in two terms: one a small error in Bouvard's eccentricity and perihelion, the other a term depending on twice the longitude. The former, of course, we could do; of the latter, there are two, viz., a term in the equation of the centre, and a term in the perturbations by Saturn. The first I have verified completely, (formula and numbers;) the second I have verified generally, but not completely. I shall, when I have an opportunity, look at it thoroughly. So much for my doubts as to any extraneous action. But if we were certain that there were any extraneous action, I doubt much the possibility of determining the place of a planet which produced it. I am sure it could not be done till the nature of the irregularity was determined from several successive revolutions."

NOTE TO No. 1.—The detection of the anomalies was published by Bouvard, in the preface to his tables of Uranus, in 1821. The date of his first suggestion of an undiscovered planet is not stated.

* The orbit with ancient and modern observations, and that from the latter only.

NOTE TO No. 2.—Bessel's researches on Uranus are contained in the volumes of Schumacher's Astronomische Nachrichten, Nos. 95 and 178. His theory of a transuranian planet is distinctly stated in his lecture to the Physico-economical Society of Königsberg, delivered February 28, 1840.

NOTE TO No. 3.—Since the receipt of Mr. Walker's manuscript, Dr. Gould, in his Report on the History of Neptune, quotes from Hansen a disclaimer of the opinion here attributed to him, having always ascribed the anomalies of Uranus to the action of *a single* transuranian planet.—*Sec. S. I.*

No. 6. Letter of M. Eugene Bouvard to Prof. Airy, Oct. 6, 1837, speaking of the observed anomalies of Uranus, he remarks:

"Cela tient-il à une perturbation inconnue apportée dans les movements de cet astre par un corps situé au delà? Je ne sais, mais c'est du moins l'idée de mon oncle."

No. 7. Answer of Prof. Airy, Oct. 12: "I cannot conjecture what is the cause of these errors; but I am inclined, in the first instance, to ascribe them to some error in the perturbations. There is no error in the pure elliptic theory, (as I found by examination some time ago.) If it be the effect of an unseen body, it will be nearly impossible ever to find out its place."

No. 8. Report of Prof. Airy to the British Association. "In 1821, Bouvard published tables of Uranus, (in the same volume with those of Jupiter and Saturn.) With respect to this planet, a singular difficulty occurs. Seventeen observations of Uranus have been found in the observations of Bradley, Mayer, &c., (for discussions of which, see the *Zeitschrift*, the *Con. des Temps*, &c.;) and since its discovery as a planet, in 1781, observations have not been wanting in any year. Now, it appears impossible to unite all these observations in one elliptic orbit, and Bouvard, to avoid attributing errors of importance to modern observations, has rejected the ancient ones entirely. But even thus the planet's path cannot be represented truly; for these tables, made only eleven years ago, are now in error nearly half a minute of space."

No. 9. The detection of some new inequalities in the theory of Uranus, by Hansen.

No. 10. The researches of Mr. J. C. Adams, first resolved on in 1841, July 3, in consequence of the remark in Prof. Airy's Report to the British Association, (No. 8.) They were commenced in earnest in 1843. The inverse problem of perturbations was solved, using the modern places exclusively, which were well represented by assuming a "circular orbit with a distance double that of Uranus" for the unseen disturbing planet.

No. 11. The proposal of the theory of Uranus as the subject of their mathematical prize, by the Royal Academy of Sciences of Göttingen, in 1842.

No. 12. The resumption of researches by Adams, in 1844, with the addition of the normal or average places from all the observations of Uranus at the Greenwich Observatory, communicated by the Astronomer Royal. The second

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Note to Nos. 3, 4, 5, and 6.—Letter of Rev. T. J. Hussey to Prof. Airy, November 17, 1834, published in the Proceedings of the Royal Astronomical Society for November 13, 1846. See also Astr. Nachr., No. 585. The title of the article is, "Account of some circumstances historically connected with the discovery of the planet exterior to Uranus," by G. B. Airy, Astronomer Royal.

Note to Nos. 6 and 7.—Airy's Account, &c.

Note to No. 8.—Proceedings of the British Association for the Advancement of Science, in 1831.

Note to Nos. 9 and 10.—See Adams' Memoir in the Appendix to the Nautical Almanac for the year 1851. See also letter of Challis to Airy, dated September 22, 1845. Proc. R. A. S., November 13, 1846.

solution was completed in September, 1845. The actual direction of Neptune is here given with a remarkably close approximation, sufficient to place it in the finder of an ordinary sweeping telescope.

No. 13. M. U. J. Leverrier's revision of the theory of Uranus, ending in a full confirmation of Bouvard's discovery of the anomalies of that planet, published on the 10th of November, 1845

No. 14. Leverrier's second Memoir on the theory of Uranus, published June 1, 1846. The first part confirms the inductive conclusions of Bessel, (No. 2,) and demonstrates that a transuranian planet is the only possible cause of the known anomalies of Uranus. The concluding portion gives the actual direction of Neptune within about a degree of the truth, and within one degree of that of Adams, in 1845.

No. 15. Sir John Herschel's address to the British Association, Sept. 10, 1846: "We see it [the probable new planet] as Columbus saw America, from the shores of Spain. Its movements have been felt trembling along the far reaching line of our analysis with a certainty hardly inferior to that of ocular demonstration."

No. 16. Leverrier's letter to Prof. Airy, June 28, 1846, showing that his new theory of Uranus, with an exterior disturbing planet, represented the quadratures as well as the oppositions, and must, therefore, give the correct radius vector.

No. 17. Prof. Airy's remark on receipt of this letter: "I had now no longer any doubt upon the reality and general exactness of the prediction of the planet's place."

No. 18. Letter of Prof. Airy to Prof. Challis, July 13, containing "suggestions for the examination of a portion of the Heavens in search of the external planet which is presumed to exist and to produce disturbance in the motion of Uranus."

No. 19. Answer of Prof. Challis, July 18: "I have determined on sweeping for this hypothetical planet."

No. 20. Observation of Neptune, August 4 and 12, 1846, by Prof. Challis, in his sweeps with the Northumberland equatorial, without knowing at the time that it was not a fixed star.

No. 21. Leverrier's third Memoir, published August 31, 1846, giving more

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Note to No. 13.—Comptes Rendus, 1845, November 10.

Note to No. 14.—Comptes Rendus, 1846, June 1.

Note to No. 15.—Airy's Memoir, see note to No. 3.

Note to Nos. 16, 17, 18, 19.—Airy's Account, &c.

Note to No. 20.—First report of Rev. J. Challis to the Syndicate of the Cambridge University, December 12, 1846. See also Astr. Nachr., 583.

Note to No. 21.—Comptes Rendus, August 31, 1846.

complete elements of the disturbing planet, and expressing an opinion, based upon his value of the mass and distance, that it would have a visible disc.

No. 22. Adams' letter to Prof. Airy, Sept. 2, 1846, giving his third solution of the inverse problem of the perturbations of Uranus. This solution (called by him Hypothesis II) gives elements nearer those of Neptune than his former ones, and representing all the normal places, except Flamsteed's, of 1690, satisfactorily. This observation was a barrier to his further approximation towards the reality, being worse represented in his II than in his I Hypothesis.

No. 23. Letter of Leverrier to Prof. Schumacher, Sept. 8, 1846, in which he remarks:

"Puissent mes recherches inspirer assez de confiance aux astronomes observateurs, pour les engager à s'occuper d'une étude attentive de la partie du ciel, où il reste sans doute à découvrir une planète dont la masse est fort considérable."

No. 24. Leverrier's unpublished letter to M. Galle, assistant at the Berlin Observatory, Sept. 18, 1846:

"La nouvelle planète, dont l'existence était démontrée, dont la place était fixée dans le ciel par les recherches qu'on vient de lire, a été trouvé à Berlin le 23d Septembre dernier. J'avais écrit le 18 Septembre, à M. Galle, pour réclamer son bien veillant concours ; cet habile astronome à vu la planète le jour ou il à reçu ma lettre."

No. 25. Dr. Galle's receipt of this letter by the post of the 23d, and his setting of the Berlin equatorial in the direction pointed out by Leverrier, so as to have the planet Neptune in the finder. His actual optical discovery of Neptune as a star not included in Dr. Bremiker's XXI hour of the Berlin star charts. His detection of its motion that evening. His full confirmation of its motion and of the discovery, on the subsequent evening, Sept. 24, 1846. His letter to Leverrier, Sept. 25:

"La planète, dont vous avez signale la position, *existe réellement.* Le même jour ou j'ai reçu votre lettre, je trouvais une étoile de 8e grandeur, qui n'était pas inscrite dans l'excellente carte Hora XXI (dessinée par M. le Docteur Bremiker) de la collection des cartes célestes publiée par l'Académie Royale de Berlin. L'observation du jour suivant décidé que c'était la planète cherchée.

No. 26. Letter of Encke to Prof. Schumacher, Sept. 25, 1846, giving the comparison of Leverrier's predicted place with actual observation, as follows:

	Leverrier's prediction, Aug. 31, 1846.	Galle's and Encke's observations.
	° ′ ″	° ′ ″
Sept. 23 and 25.—Neptune's heliocentric longitude . . .	374 58 0	375 52 45
latitude . . .	0 0	0 30 54
Daily geocentric retrograde motion in longitude	68.7	73.8
Apparent diameter	3.3	2.5

NOTE TO No. 22.—Airy's Account, &c.
NOTE TO No. 23.—Astr. Nachr., 586.
NOTE TO No. 24.—Additions ā la connaissance des Temps, 1849. Leverrier's Memoir, dated Paris, October 5, 1846.
NOTE TO No. 25.—Prof. Schumacher's Circular of September 26, 1846. See also note to No. 24.
NOTE TO No. 26.—Prof. Schumacher's Circular of September 26, 1846.

No. 27. Leverrier's remark on the receipt of Dr. Galle's letter of Sept. 25, in reply to his of the 18th:

"Ainsi, la position avait été prévue à moins d'un degré près. On trouvera cette erreur bien faible, si l'on réflechit à la petitesse des perturbations dont on avait conclu le lieu de l'astre. Ce succès doit nous laisser espérer qu' après trente ou quarante années d'observations de la nouvelle planète, ou pourra l'employer, à son tour, à la découverte de celle qui la suit dans l'ordre des distances au soleil. Ainsi de suite; on tombera malheureusement bientôt sur des astres invisibles, à cause de leur immense distance au soleil, mais dont les orbites finiront, dans le suite des siècles, par être tracées avec une grande exactitude, au moyen de la théorie des inégalités séculaires."

No. 28. Letter of Challis to Schumacher, Oct. 21, 1846, giving Adams' elements of Neptune from recent observations.

No. 29. Encke's Memoir read, Oct. 22, 1846, to the Royal Academy of Sciences of Berlin, giving the provisional elements of the planet, and naming it Neptune. Encke remarks: "Neptune's distance from the Sun cannot differ much from 30, while Leverrier's elements give 33. The period must be shorter than Leverrier's. If circular, it would be 165 years."

No. 30. Detection of Lalande's printed Histoire Celeste observation of Neptune, May 10, 1795, and restoration thereby of fifty-two years to the historical period of our knowledge of the place of this planet, by the author of this Memoir.

No. 31. Prof. Peirce's communication to the American Academy of Arts and Sciences, March 16, 1847, giving the result of his revision of the theories of Adams and Leverrier, and of my period and present distance in the elements of Feb. 5. Prof. Peirce, in this memoir, pronounces the opinion that the theoretical researches of Adams and Leverrier do not comprise the physico-mathematical solution of the problem that belongs to the case of Neptune, and that Dr. Galle's discovery must, therefore, be considered "a happy accident."

No. 32. The detection of the Lalande observation of May 10, 1795, by Dr. Petersen, of the Altona Observatory, March 17, 1847.

No. 33. Leverrier's remark on communicating the Washington and Altona researches relative to the Lalande observation, that—

"Cette petitesse de l'eccentricité qui semble résulter des calculs de M. Walker serait incompatible avec la nature des perturbations de la planète de Herschel."

So strong was his conviction of the force of this remark, that he adds:

"Mais il se peut très bien que cette petitesse de l'eccentricité ne soit pas une consequence nécessaire de la représentation de l'observation de Lalande."

Note to No. 27.—See note to No. 24.

Note to No. 28.—Schumacher's Astr. Nachr., No. 583.

Note to No. 29.—Schumacher's Astr. Nachr., No. 588.

Note to No. 30.—See Lieut. Maury's Official Report to the Secretary of the Navy, published February 9, 1846, in the Washington Union.

Note 1st to No. 31.—See Proceedings of the American Academy of Arts and Sciences, March 18, 1846.

Note to No. 32.—Comptes Rendus, March 29, 1847; also Astr. Nachr., No. 595.

Note to No. 33.—Comptes Rendus, March 29, 1847.

No. 34. The restoration of Lalande's suppressed manuscript observation of Neptune of May 8, 1795, by M. Victor Mauvais.

No. 35. The computation of new elements of Neptune, by Adams, based on the Lalande observations, confirming mine of February 6, and the revision of his theory of Neptune, according to his remark, "justifying some skepticism as to former conclusions."

No. 36. The remark of Prof. Airy on the same occasion, that "much was owing to chance" in the discovery of Neptune.

No. 37. The demonstration by Prof. Peirce, in the summer of 1847, of the impossibility of explaining the normal places of Uranus and Neptune by any assignable mass of the latter, if we assume its period to be double that of Uranus.

No. 38. The computation of the perturbations of Neptune for the historical dates of the normal places, on the hypothesis of the double period of Uranus, and with the best elements obtained by me previous to this work by Prof. Peirce, communicated to me early in November, 1847.

No. 39. Computation of the first elliptic elements of Neptune, by the author of this memoir, from the normal places in 1795, 1846, and 1847, using Peirce's first tables of the perturbations, communicated to Prof. Peirce in the latter part of November, and inserted in his memoir of December 7, 1847.

No. 40. New computation of tables of the perturbations of Neptune on the basis of my recent and first elliptic elements, by Prof. Peirce, communicated to me in a letter dated January 12, 1848, and read to the American Academy, April 4 of that year.

No. 41. Discussion of 650 observations of Neptune, formation of new normal places, and computation of the second elliptic elements, communicated to Prof. Peirce, March 6, 1848.

No. 42. The discovery of Neptune's satellite by Mr. W. Lassell, of Liverpool, in 1846. The confirmation of this discovery, and the measures of its elongation, in the autumn of 1847, by Messrs. Lassell, Bond, Struve, and Mitchel.

No. 43. Completion of the theory of Uranus, and perfect representation of all the historical normal places of Neptune, by Prof. Peirce, using as a basis the Messrs. Bond's measures of the elongation of its satellite and my second elliptic elements, communicated April 4, 1848, to the American Academy.

Note to No. 34.—Comptes Rendus, April 19, 1847.
Note to Nos. 35 and 36.—Proceedings R. A. Soc., Vol. VII, for June 11, 1847.
Note to No. 37.—Letter to S. C. Walker.
Note to No. 38.—Proceedings A. A. A. S., December 7, 1847.
Note to No. 39.—Proceedings A. A. A. S., December 7, 1847.
Note to Nos. 41 to 43.—Proceedings A. A. A. S., April 4, 1848.

No. 44. These events, comprising a period of a quarter of a century, have ended by enriching astronomy with a new primary planet and satellite, and with the removal from the pages of its history of all the anomalies of Uranus, which for many years had formed its last and only remaining opprobrium.

SECTION 2.

DETAILED ACCOUNT OF THE DISCOVERY OF THE TWO ANCIENT PLACES OF NEPTUNE, OBSERVED BY LALANDE, JUNE 8 AND 10, 1795.

No. 21. During my connexion with the National Observatory, under the direction of Lieut. Maury, the news of the optical discovery of Neptune was received on the 24th of October, 1846, and the duty of making a series of investigations, with reference to this new member of our system, having been assigned to me by the Superintendent early in November, I commenced the researches, of which the following is an account:

Mr. E. C. Herrick, of New Haven, had called attention to the fact of the proximity of position and probable identity of Neptune with the Wartman planet of 1831. My first labors were directed to the search for the approximate elements of the two planets, which soon led to the conclusion that they were not the same, and that no satisfactory orbit could be formed for Wartman's planet from the imperfect tracing of its path in the *Comptes Rendus* for 1836.

No. 22. The first inquiry concerning the motions of Neptune, had shown the near approach of its orbit to the circular form. The same analogies of the system that furnished Adams and Leverrier the clue to their analytical prediction of its place, in 1845 and 1846, were to serve as guides in the first attempt to sketch its orbit.

No. 23. It was naturally to be presumed that the inclination and eccentricity of this primary planet were small, and that the daily variations of the radius vector and angular orbital motion, impressed by the sun, at a distance of nearly double that of Uranus, must be very small fractions of their total values. Hence, in a first approximation, these daily variations, as well as their differences and terms of a higher order, might be neglected.

No. 24. Accordingly I commenced with the simple hypothesis of constancy of the radius vector from September 24 to November 21, a period of 58 days, leaving the character of the orbit, whether nearly circular or much flattened, to be the result of the investigation.

Nine European observations combined furnished one *normal place of Neptune, for September 24, 1846. Three Washington observations, October 24, and three more, November 21, completed the three observed places. Commencing with the trial of radii vectores 33 and 34, which include Leverrier's and Adams' hypothetical values, 33 was found too great, and the scale was extended downwards to 32, 31, 30, and 29.

I subjoin the table of the computed daily siderial angular motions for the three intervals of 30 days from September 24, 58 days from September 24, and 28 days from October 24, for this scale of assumed constant radii vectores. They are the results of an approximate computation only. r is the radius vector, ν' is the daily siderial angular motion for the first 30 days, ν for the whole term of 58 days, $\nu_{\prime}$ for the last 28 days. μ is the mean daily siderial motion for $r = a =$ semi axis major.

r	ν^1	ν	$\nu_{\prime}$	μ
	$''$	$''$	$''$	$''$
34	12.8	16.7	19.7	17.90
33	14.6	17.7	20.3	18.71
32	16.6	18.8	20.8	19.60
31	19.4	20.1	21.2	20.56
30	21.7	21.6	21.6	21.58
29	24.1	23.4	22.0	22.67

The same analogies that led to the assumption of the *constancy* of the radius vector, also lead to the conclusion that ν must be nearly constant. Accordingly, the radius vector to be interpolated from this table was that in which $[(\nu - \nu')^2 + (\nu - \nu_{\prime})^2]$ should be a minimum.

A slight inspection of the table shows that this value of r is very nearly 30.0, and that since for this value $\nu' = \mu$ $\nu = \mu$, and $\nu_{\prime} = \mu$ very nearly, therefore $a = r$

* By means of my approximate Ephemeris, I was able to compute the value of c, or the mean of the second differences of the planet's daily places, in R. A. and Dec., with a certainty of an error not exceeding $0''.03$. The group of observations of any seven consecutive nights were reduced to the corresponding value for the 4th night by the following formula, in which only the difference c of the daily motions, and not the daily motions themselves, are employed:

Making n_n = the number of observations for the nth night,

$$A = \left(2\, n_4 \qquad \right)$$

$$A_1 = 4\left(\frac{n_3 \times n_5}{n_3 + n_5}\right)$$

$$A_2 = 4\left(\frac{n_2 \times n_6}{n_2 + n_6}\right)$$

$$A_3 = 4\left(\frac{n_1 \times n_7}{n_1 + n_7}\right)$$

We have for the normal place on the 4th night,

$$\alpha = \frac{1}{2\,\Sigma\,A}\left[A\,\alpha_4 + A_1\,(\alpha_3 + \alpha_5 - c) + A_2\,(\alpha_2 + \alpha_6 - 4\,c) + A_3\,(\alpha_1 + \alpha_7 - 9\,c)\right]$$

very nearly. In other words, the orbit approaches very nearly to the circular form; and that which was at first inferred from the analogies of the solar system, (viz., the smallness of the eccentricity,) seemed to be confirmed by deductions* from actual observation.

No. 25. Being now prepared to commence a rigorous computation of the *circular* elements, on the hypothesis of a uniform radius vector, $r = a$, I used a normal place of the 26th of September, and another place deduced from my own observations with the Washington Equatorial, December 26. On that night I compared Neptune in right ascension, by transits, 33 times with each of the two Enckian stars, which have been used for such comparisons, from its discovery by Galle, to the middle of January last. I also compared it 11 times, in declination with the same stars, with the filar micrometer.

After correcting the observed places for parallax, and the dates for aberration time, (which amounts to about 4 hours,) I computed the elements in the table below. The data for the computation were obtained as follows: The planet's mean place, as a fixed star, for January 1, 1847, was derived from the observations; the correction for planetary parallax was applied. The R. A. and Dec. were then reduced to their equivalent geocentric longitude α, and latitude δ, referred to the mean equinox of January 1, 1847, with the mean obliquity. The places are—

†Greenwich mean time - - -	θ , θ' =	1846^y $268^d.33333$ +	;	1846^y $359^d.5$
Aberration time - - - - - -	$\Delta\theta$, $\Delta\theta'$ =	— 0.16755	;	— 0.17563
Reduced time - - - - - - -	t , t' =	$268^d.165783$	;	$359^d.32437$
Planet's geo. lon. - - - - -	α , α' =	325° 49′ 1″.48	;	326° 21′ 2″.64
Planet's geo. lat. - - - - -	δ , δ' =	— 0 31 57 .81	;	— 0 31 26 .37
Concluded hel. lon. - - - -	λ , λ' =	326 59 5 .40	;	327 31 59 .0
Concluded hel. lat. - - - -	β , β' =	— 0 31 7 .089	;	— 0 32 4 .791
	$\lambda - \lambda'$, $\beta - \beta'$ =	+ 0 32 53 .60	;	+ 0 0 57 .702
Orbital longitudes - - -	$\pi + v$, $\pi + v'$ =	326 59 32 .73	;	327 32 27 .09
True sid. mot. - - - - -	$v' - v$ =	+ 0 32 54 .36	;	
Daily do. - - -	n =	21″.658575	;	
Mean daily do. for $r = a$ = 29.93995 ,	μ =	21″.658575	;	

* The possible accidental case of $r = a$, in a very eccentric orbit, was rejected from its extreme improbability. This case occurred in a solution which I obtained about the 20th of January, 1847. The elements obtained were—

π = 237° 23′ 2″ mean equinox. January 1, 1847.
☊ = 129 48 23 " "
i = 1 45 20
e = 0.1927122
μ = 21″.5416
True anomaly v = 89° 48′ 0″ September 28, 1846, mean noon, Greenwich.

This solution was rejected, because it was found that a change of one second in either of the four geocentric places used would be sufficient to remove more than half this eccentricity. It may not, perhaps, be improper to remark, that the orbits obtained by M. Valz, of Marseilles, and published in the Comptes Rendus, and in the Astronomische Nachrichten, which resemble this result, may have owed their large eccentricity to the very small errors of the Marseilles observations.

† The earth's true place is taken out for the time θ, and θ'. The earth's latitude was not taken into account. Its maximum effect is 0″.02 on the computed geocentric place of Neptune.

The smallness of the values of $\lambda' - \lambda$, and $\beta' - \beta$, on which the concluded position of the plane of the whole orbit depends, would have deprived this result of all its value, if the errors of observation had not also been extremely small, so as to bear a corresponding proportion to the measured path. There is, however, one advantage in the smallness of $\nu' - \nu$, that the errors arising from the neglected terms, (the daily variations of r and ν,) are also very small.

I subjoin the Disturbed Elements I, as far as they could be completed at this time.

DISTURBED ELEMENTS, I.

Perihelion point - - - - -	π	=	unknown.
Ascending node - - - - -	Ω	=	129° 48′ 23″.2 m. eq. Jan. 1, 1847.
Inclination - - - - - - -	i	=	1° 45′ 19″.9
Eccentricity - - - - - -	e	=	0.0
Mean daily siderial motion -	μ	=	21″.65857
Epoch of mean longitude - -	ϵ	=	unknown.
Period in tropical years - - -	T	=	163^y.8259
True daily angular motion - -	ν	=	21.65857
Heliocentric Longitude - - -	λ	=	326° 59′ 41″.5 1847, Sept. 28th, m. noon, Green.

No. 26. With the Disturbed Elements I, I computed with every possible precision an Ephemeris of Neptune, from August 1, 1846, to February 1, 1847, and then compared with it all the standard observations yet received, after applying all the small corrections, and treating them in the same manner as the places of September 26 and December 26, mentioned above. The available observations comprehended one hundred and sixteen nights' works in all. They may be thus classified:

MERIDIAN OBSERVATIONS.

No. of nights observed.	Observatory.	Instrument.	Observer.
5	Göttingen,	Meridian Circle,	Gauss,
13	Altona,	"	Petersen,
17	Hamburg,	"	Rumker,
4	Dorpat,	"	Mädler,
4	Königsberg,	"	Wichmann,
3	Geneva,	"	Plantamour,
2	Turin,	"	Plana,
8	Cambridge, E.	"	Challis,
5	Washington,	Transit Inst.,	Almy,
4	"	"	Keith,
6	"	Mural Circle,	Coffin,
1	"	"	Page,
3	"	Ertel Mer. Circle,	Maynard,
5	"	"	Hubbard.

DIFFERENTIAL MEASURES.

No. of nights observed.	Observatory.	Instrument.	Observer.	Star of Comparison.
10	Berlin,	Great equatorial,	Encke & Galle,	*b* of Encke.
6	Cambridge, E.	"	Challis,	7648 B. A. C.
7	Washington,	"	Maury,	7648 & *b*.
11	"	"	Walker,	7648 & *b*.
4	"	"	Hubbard,	7648 & *b*.

The place of the star *a*, viz., 7648 B. A. C., rested upon the following authorities: Piazzi, Mayer, Taylor, Challis, 6 obs.; Plantamour, 4 obs.; Plana, 1 obs.; Washington Observatory, 25 meridian observations. The above are direct observations of 7648 B. A. C. There were also 5 Berlin and 3 Washington equatorial comparisons of 7648 B. A. C. with Neptune directly, or through *b, on nights when that planet was observed on the meridian, and its place reduced to a common date.

The other star *b*, (Encke's *a,) 9th mag., has for its place the following authorities: Bessel's Zones, Encke & Galle, 2 nights' comparisons with 7648 B. A. C.; Encke, 5 nights' comparisons with Neptune, referred on those nights to 15 meridian observations; Maury 6, Walker 10, nights' comparisons with 7648 B. A. C.

The mean places of the two stars from all these authorities for January 1, 1847, were adopted, as follows:

			°	′	″		°	′	″
$a =$	*7648 B. A. C. 7th mag.,	R. A. 1847,	327	32	16.79,	Dec., 1847	— 13	23	39.17
$b =$	star a of Encke, 9th mag.,	"	327	57	42.81,	"	— 13	25	57.22

In this manner I obtained, from the above list of observations of Neptune, 16 normal places, which are subjoined, together with the corrections of the Ephemeris. In this list, α and δ are the mean places of Neptune as a fixed star in geocentric longitudes and latitudes, referred to the mean equinox and mean obliquity of January 1, 1847, corrected for planetary parallax, but not for planetary aberration.

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* In my letter of February 13, 1847, to Dr. R. M. Patterson, Vice President of the Am. Phil. Soc., I stated that I did not think that the error of either of these stars' places much exceeded one second of space. Subsequent events have strengthened this conclusion.—Author.

FIRST GEOCENTRIC NORMAL PLACES OF NEPTUNE.

No. of place.	Mean time, Greenwich, 1846.	Obs'd Geo. Long. α	No. of Obs.	Obs'd Geo. Lat. δ	No. of Obs.	Obs.—Eph. I. $\Delta\,\alpha$	Obs.—Eph. I. $\Delta\,\delta$
	d	° ′ ″		° ′ ″		″	″
1	215.56696	327 9 49.34	(1)	0 31 36.24	(1)	− 16.75	− 0.63
2	223.54405	326 57 9.04	(1)	44.09	(1)	− 7.27	− 1.03
3	270.5	325 46 25.82	(16)	57.99	(16)	− 1.02	+ 0.84
4	276.5	39 54.23	(13)	56.15	(13)	+ 0.27	+ 1.51
5	282.5	34 16.11	(13)	56.09	(13)	+ 1.12	+ 0.03
6	290.5	28 21.99	(12)	53.16	(12)	+ 3.13	+ 0.80
7	298.5	24 25.25	(18)	51.13	(19)	+ 4.19	+ 0.56
8	306.5	22 32.46	(6)	47.61	(6)	+ 3.02	+ 0.23
9	313.5	22 40.00	(4)	45.15	(3)	+ 2.40	− 0.68
10	319.5	24 6.40	(4)	41.51	(6)	+ 1.95	+ 0.51
*11	325.5	26 50.59?	(4)	37.30?	(4)	+ 3.77?	+ 2.21?
12	334.5	33 9.44	(7)	33.92	(6)	+ 2.46	− 1.13
13	345.5	44 26.93	(4)	30.79	(4)	+ 0.96	− 0.03
14	353.5	54 58.01	(2)	27.10	(2)	− 0.72	+ 1.51
15	359.5	326 4 2.54	(3)	26.04	(3)	− 0.23	+ 0.77
16	372.5	326 26 39.11	(3)	0 31 23.60	(3)	− 4.40	+ 1.28

A slight examination of the corrections of the Ephemeris from Disturbed Elements I, seemed to show that the orbit deviated sensibly from the circular form. Accordingly the next step in the investigation was to remove the restriction $r = a$, $\nu = \mu$, by merely supposing the radius vector constant during the observed interval, and leaving ν to take such a value as the observations should require:

For this purpose, let $x = 50 \times \Delta\, r$

$$y = 10 \times \Delta\, \nu$$

$z = \Delta\, v_{300} =$ correction of Neptune's true long. by Ephem., Oct. 29, 1846.

$\nu_{,} =$ daily motion in true long.

From the 16 normal places, 9 equations of condition were formed with equal weights. No. 11 was rejected. Equation 1 is the third of the mean of Nos. 1 and 2. Equations 2, 3, 4, 5, 6, were formed from Nos. 3, 4, 5, 6, 7, respectively. Equation 7 is the mean of Nos. 8, 9, and 10. Equation 8, of Nos. 12 and 13; and equation 9, of Nos. 14, 15, and 16.

After reducing the corrections of the geocentric to their equivalent projections in heliocentric longitude and latitude, ($\Delta\,\lambda$ and $\Delta\,\beta$,) and computing the coefficients of x and y, (that of z is always + 1,) the 9 conditional equations from the longitudes were,

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*The 11th normal place was properly rejected in consequence of its difference from the others. I have since found that one of the four observations used was erroneous.

						Residual error.
					$''$	$''$
1	;	$0 = -\,0.303 \times x$	$-\,2.700 \times y$	$+\,0.333 \times z$	$+\,3.88$;	$-\,0.08$
2	;	$= +\,3.016$	$-\,3.000$	$+\,1$	$+\,1.00$;	$+\,0.49$
3	;	$= +\,3.363$	$-\,2.400$	$+\,1$	$-\,0.27$;	$+\,0.19$
4	;	$= +\,3.685$	$-\,1.800$	$+\,1$	$-\,1.10$;	$+\,0.22$
5	;	$= +\,4.038$	$-\,1.000$	$+\,1$	$-\,3.07$;	$-\,1.03$
6	;	$= +\,4.268$	$-\,0.200$	$+\,1$	$-\,4.12$;	$-\,1.31$
7	;	$= +\,4.594$	$+\,1.267$	$+\,1$	$-\,2.44$;	$+\,1.03$
8	;	$= +\,4.248$	$+\,3.950$	$+\,1$	$-\,1.73$;	$-\,0.13$
9	;	$= +\,3.332$	$+\,6.133$	$+\,1$	$+\,1.81$;	$-\,0.16$

Whence the three normal equations,

$$\begin{aligned}
0 &= 118.879 \times x + 7.477 \times y + 30.443 \times z - 45''.629 \\
0 &= 7.477 + 85.149 + 0.250 + 1''.687 \\
0 &= 30.443 + 0.250 + 8.111 - 8''.627
\end{aligned}$$

and—

$$\text{I.}\quad \begin{cases}
x = +\ 3''.255712\ , & r = 29''.939950 + \dfrac{x}{50} = 30''.005064 \\
y = -\ 0''.272963\ , & \nu = \dfrac{v' - v}{t' - t} = 21''.65789 \\
z = -\,11''.1475\ , & \omega = \pi + v \text{ Sept. 28, 1846} = 326^\circ\ 59'\ 34''.74
\end{cases}$$

The values of ν and $\pi + v$ are the result of a new computation with the new radius vector, 30.005064. The sum of the squares of the errors in longitude of Disturbed Elements I for the 9 equations is 55''.96. The sum of the similar quantities for the Disturbed Elements II, is 4''.21, which is the sum of the squares of 9 errors, each comprising the united error of theory and observation.

In my paper on meteors, in the Memoirs of the American Philosophical Society, are found the well known equations—

$$\text{II.} \quad . \ . \ . \ . \ . \ . \ . \ . \ . \ . \quad \frac{1}{a} = \frac{2}{r} - g^2 = \frac{2}{r} - \left(\frac{r\,n}{\text{Gauss' } k}\right)^2$$

$$\text{III.} \quad . \ . \ . \ . \ . \ . \ . \quad e\,r \cos v = a \cos^2 \phi - r = a\,(1 - e^2) - r$$

In which g is the true angular velocity, in units, of the earth's mean angular velocity. Equation II, by means of r and n in Elements II, gives $a = 30.200585$. Equation III, gives the value of ω for any assumed value of the eccentricity e. It is of the second degree, and gives the value of ω either in the first or fourth quadrant. It is not possible, from the process above pursued, to decide between the two quadrants of ω. By hypothesis, the daily variation of r was neglected. Hence it remains uncertain whether the r of Disturbed Elements II, belongs to a value of v, in the first or fourth quadrant.

Disturbed Elements II, as far as they could be completed at this time, are here appended:

DISTURBED ELEMENTS II.

π = unknown.
Ω = 129° 48′ 23″.2 M. eq. January 1, 1847.
i = 1° 45′ 19″.9
e = unknown.
μ = 21″.37881
ϵ = unknown.
T = 165^{y}.9703
ν = 21″.65789
λ = 326° 59′ 34″.74 1847, September 30, m. noon Greenwich.

No. 27. It is possible that the insertion in the conditional equations of two more terms for the daily variations of r and ι might have decided this point. Before attempting this inquiry, it was concluded to examine the ancient catalogues, for the purpose of detecting Neptune as a missing star. Among the catalogues to be resorted to were Bradley's, Lacaille's, Mayer's, Lalande's, Piazzi's, Bessel's, Brisbane's, and Taylor's. The first three of these catalogues do not usually include stars of the magnitude 7.8. In the recent publication of Piazzi's original observations by the Vienna Observatory, extending from 1792 to 1798, I do not find among the stars observed by Piazzi, and not subsequently identified, any which come within reasonable limits of Leverrier's computed place on the nights of observation. From 1821 to 1832, the term of Bessel's Zone observations, Neptune was near the southern point of the Ecliptic, and consequently below his limits. The Brisbane catalogue is chiefly confined to stars of more than 30° of south declination. Taylor's observations at Madras are usually limited to the reviewing of stars contained in previous catalogues. There remained only Lalande's catalogue, which offered hopes of success at present.

I had expected that a list of stars, from the Histoire Céleste Français, in the Neptunian region, on the nights of observation, would comprise a hundred or more.

No. 28. On the 2d of February were commenced the computations for the formation of the trial catalogue. This was easily effected. After making a sketch of the Neptunian regions for the dates from 1790 to 1800, I soon came to the conclusion that the nights of the 8th and 10th of May, 1795, were the only ones that afforded a reasonable prospect of furnishing an observation of Neptune, and accordingly computed for the evening of the 10th of May, the limits of the Neptunian region, or in other words the *locus* of Neptune as a fixed star, referred to the apparent equinox of May 10, 1795, with the node, inclination, orbital longitude, and radius vector of my Disturbed Elements II, and various average angular motions from 21″.3 to 21″.9, for the interval

from that date to September 26, 1846. I then reduced the apparent right ascension and declination of these computed places of Neptune to Lalande's clock and quadrant reading, for May 10, 1795. These would in this search answer, without change, for the 8th. The actual results of the approximate computation then made are as follows:

Magnitude.		Lalande's Clock time.	Lalande's Quadrant reading.		
♆ if in H. C. ⁎ 7.8	,	$13^h\ 59^m\ 2^s$	59° 6′ 7″	,	supposed western limit.
"		14 5 17	59 37 21	,	most probable place.
"		14 11 32	60 8 35	,	supposed eastern limit.

I next proceeded to prepare a list of stars on the nights of May 8 and May 10, having a clock reading from $13^h\ 50^m$ to $14^h\ 20^m$, and within 15′ north or south of the quadrant reading interpolated for the clock time from the above *locus*. All the stars in this region, May 8, were below the 7.8 magnitude, and were, moreover, found in Bessel's Zones. The only star in this region on the 10th of May, 1795, of the proper magnitude, and not included in Bessel's Zones, read thus:

Magnitude.	Clock time of Transit.	*Quadrant reading.
⁎ 7.8	14° 11′ 23″.5	60° 7′ 19″:

The place from the list of *loci* gave for this clock time—

Neptune as a ⁎ 7.8 , $14^h\ 11^m\ 23^s.5$, 60° 7′ 50″

This astonishing coincidence was noticed by me in the evening of the 2d February, (the weather being stormy.) It could not for a moment be doubted that the star and planet were the same. The limits, it was believed, were sufficiently extensive to include the Neptunian region. The magnitude 7.8 of Neptune was one seldom omitted by Lalande. It was evident that Lalande had bestowed his usual pains upon this region. No other star of the Histoire Céleste, even if now missing, could with reason be supposed to be Neptune. It required only that this star on search should be missing, to furnish a complete confirmation. Accordingly, I drew up a statement to Lieut. Maury, the Superintendent, dated February 2, giving an account of my labors, and mentioning these *loci*, the particulars of the remarkable coincidence, and the grounds that induced me strongly to believe in their identity, and, as a necessary consequence, that the star would not be found in the group in which it had formerly been observed. The Superintendent and my coadjutors in the Observatory, Professors Coffin and Hubbard, after examining the list of Lalande's stars in the Neptunian

* I did not notice till two weeks later the (:) colon placed after this observation by Lalande, indicating that the error in declination might amount to 5′. My attention was first called to this doubtful circumstance by Prof. Peirce.

region, of May 8 and 9, 1795, agreed with me in the opinion that this star was Neptune, if Lalande had observed that planet at all, and that on searching the region it would prove to be missing. So fully were we convinced that the result would be in accordance with our anticipation, that on the 3d of February an account of what had been done, and what was expected, was transmitted to the following persons, not connected with the Observatory, namely, to Lieut. Gilliss, U. S. N., to Professor A. D. Bache, LL. D., and Professor Jos. Henry, LL. D.

No. 29. The weather still continued cloudy until the afternoon of February 4th, when it became clear. On the evening of this day Professor Hubbard was directed to observe the stars of the following list, which I had prepared, for the purpose of testing the question of the presence or absence of the star believed to be the planet Neptune.

This list, for convenience sake, was taken from Hussey's XIV Hour in the Berlin Star Charts, the *loci* of Neptune having been changed to mean places as a fixed star, January 1, 1800.

The list used by Prof. Hubbard, February 4, 1847, was as follows:

No.	Magnitude.	R. A. 1800. h. m. s.	Dec., 1800. ° ′
1	9	14 8 1	— 11 39.2
2	9	14 8 3	11 27.5
3	8	14 8 5	11 8.0
4	8	14 10 0	11 26.5
5	9	14 10 27	10 55.1
6	8	14 10 33	10 28.4
7	9	14 11 27	10 53.3
8	8	14 12 0	11 8.3
*9	7.8	14 12 1	11 21.0 ♆ ?
10	6	14 12 41	10 47.6
11	9	14 13 20	11 25.8
12	7	14 13 57	10 45.2
13	9	14 15 53	10 42.9
14	8.9	14 20 32	10 58.4
Reduction to 1847		+ 2 31.2	— 13.2

On the morning of the 5th, Prof. Hubbard reported to Lieut. Maury that he had verified our expectations, in so far as related to the absence of the star No. 9 of the guide catalogue. He had found each of the other 13 stars twice. He had repeatedly brought the star No. 8 to the proper place, in order that No. 9, if now in the Heavens, should be in the field. It was not now in the Heavens.

No. 30. If it had been strongly expected that the star would be reported to be missing, how much must the belief in its identity with Neptune be increased by this report. I immediately commenced, February 5, to compute the Dis-

turbed Elements III, of Neptune, upon the hypothesis that Lalande had observed it upon the 10th of May, 1795. These elements were completed February 6. They were only approximate; yet they were such as, in my opinion, confirmed the period of the Disturbed Elements II, and established the smallness of the *eccentricity of Neptune, viz., 0.0088407.

I subjoin the Disturbed Elements III, as they were published in the Union, on the 9th of February, 1847.

DISTURBED ELEMENTS III, OF NEPTUNE, COMPUTED ON HYPOTHESIS OF IDENTITY WITH THE LALANDE STAR OF MAY 10, 1795.

$$\left.\begin{array}{rl} \pi = & 0^\circ\ 12'\ 25''.51 \\ \Omega = & 131\ \ 17\ \ 35\ .80 \\ i = & 1\ \ 54\ \ 53\ .83 \\ e = & 0.0088407 \\ \mu = & 21''.3260 \\ \varepsilon = & 328^\circ\ 7'\ 56''.64 \\ \text{Radius vector } r = & 30.02596 \\ \nu = & 21''.64553 \\ \mathrm{T} = & 166^{y}.38134 \end{array}\right\}\ \text{1847, September 28, m. noon, Greenwich.}$$

In order to present the question of identity or non-identity in a more conclusive form, I reviewed my computations of the *loci* for the 10th of May, making them functions of the increasing values of the eccentricity e, from the minimum $e = 0.006457$, viz., $v = 0$, to $e = 0.06$ for $v = \pm 87^\circ.2$.

The computations were made by the equation,

$$\cos v = \frac{a\,(1 - e\,e)}{e\,r} - r$$

For $v = 0$, e is 0.006474. For $v = \pm 90^\circ$, e is 1. Hence the limit $v < \pm 90^\circ$ for the true anomaly, January 1, 1847. When we consider that between $+ 90^\circ$ and $- 90^\circ$, all values of v for completion of Elements II, are *a priori* equally plausible, the following table is readily formed:

---

*My most recent value of this element, for Elliptic Elements II, is 0.00871946, being a diminution of 0.0001212. The remarks of M. Leverrier, in noticing these elements, Comptes Rendus, for March 29, 1847, that this smallness of my concluded eccentricity was "incompatible with the nature of the residual perturbations of Uranus;" but "perhaps it was not a necessary consequence of the representation of the Lalande observation," cannot be sustained. Prof. Peirce has demonstrated its perfect compatibility with the anomalies of Uranus. Adams has confirmed the necessity of this smallness for the representation of the Lalande observation. See Proceedings R. Ast. Soc., Vol. VII, p. 269, May 14, 1847; also Astronomische Nachrichten, No. 600. Adams' value is even smaller than that of Elements III, by 0.000457.

The first limit is ; $v = \pm 90°$ for the true anomaly, January 1, 1847.

The second limit is ; $e < 0.01$; with the *a priori* probability $= \frac{50°.1}{90°}$ &c.

$$; e < 0.02 ; \qquad = \frac{72°.2}{90°}$$

$$; e < 0.03 ; \qquad = \frac{79°.2}{90°}$$

$$; e < 0.04 ; \qquad = \frac{83°.0}{90°}$$

$$; e < 0.05 ; \qquad = \frac{85°.4}{90°}$$

$$; e < 0.06 ; \qquad = \frac{87°.2}{90°}$$

LOCI OF NEPTUNE, MAY 10, 1795, BY ELEMENTS II.

		R. A. ♆ Equinox of 1800. h. m. s.	Dec. ♆ Equinox of 1800. ° ′
For $+ v$, and $e =$	0.06	13 45 50	— 9 3.1
"	0.05	13 49 48	— 9 24.9
"	0.04	13 53 51	— 9 47.0
"	0.03	13 57 52	— 10 8.6
"	0.02	14 1 56	— 10 29.6
"	0.01	14 6 21	— 10 53.4
$v = o$	0.006474	14 9 18	— 11 8.7
$- v$	0.01	14 12 9	— 11 23.4
"	0.02	14 16 36	— 11 44.5
"	0.03	14 20 35	— 12 6.1
"	0.04	14 24 29	— 12 25.3
"	0.05	14 28 19	— 12 44.2
"	0.06	14 32 8	— 13 2.6

The list of stars within 15′ of these *loci* in the Histoire Céleste, as found in Hussey's XIV Hour, is as follows:

Trial Catalogue.	Mag.	R. A. 1800 h. m. s.	Dec. 1800. ° ′	Authority.
No. 1	9.10	13 50 36	— 9 24.0	L.
2	7.8	13 52 48	— 9 58.8	L.
3	7.8	13 52 53	— 9 45.7	L. B.
4	8.9	13 57 13	— 10 11.7	L. B.
5	9	13 59 54	— 10 26.4	L. B.
6	8	14 0 0	— 10 26.4	L. B.
7	8	14 12 0	— 11 8.3	L. B.
♆ ? 8	7.8	14 12 0.9	— 11 20.96	L.
9	8	14 29 37	— 13 10.7	L. B.

The stars seen afterwards by Bessel, marked B, were at once excluded, leaving Nos. 1, 2, and 8, not in the Zones of Bessel. Of these No. 1 was excluded

by its magnitude, (9.10;) No. 2, in my opinion, by being 17′ south of the geocentric path. There remained, then, in all the Histoire Céleste, only one star (No. 8) that could have been the planet Neptune.

The fact that this star afforded the only chance for a Lalande observation of Neptune, and that it was now missing, could leave little doubt on the question of identity. Another consideration strengthened the probability of this conclusion; and this was, its nearness to the point of the *loci* which had a maximum of plausibility, (viz., that of $\left(\frac{d\,v}{d\,e}\right) =$ a maximum , $v = 0$).

No. 31. The first public announcement of the probable discovery of a Lalande observation of Neptune was made 7 days after its date, viz., on the 9th of February, in the official organ of the Government, (the Washington *Union*,) in a letter of Lieutenant Maury to the Secretary of the Navy, the Hon. John Y. Mason, dated February the 8th.

The circumstance of the (:) colon placed after the Lalande observation of No. 8, was at this time the only one which was calculated to throw a doubt on this conclusion. Stars Nos. 7 and 8 have nearly the same right ascension, and differ 12′.7 in declination. One is marked doubtful in R. A.; the other in Dec. Could they not have been the same? Is any star missing from the heavens? Did Lalande observe Neptune at all? Were not the limits of the computed *loci* of Neptune, May 10, 1795, too restricted? Is the observed path of Neptune (of only six months) sufficiently well known, to overturn the limits established by Leverrier for his hypothetical planet, viz., a period of more than 209 years, and an eccentricity greater than the present assumed maximum limit? These were the difficulties under which the hypothesis of identity labored in this country, till the arrival at Washington, (May 19, 1847,) of the news of *M. Mauvais' discovery of the other Lalande observation of Neptune, of May 8, 1795.

No. 32. I shall not here dwell on the particulars relative to the Mauvais discovery. The news of the probable discovery of the Lalande observation of May 10, reached Leverrier, at Paris, on the same day from Washington and from Altona, (Mr. Peterson's discovery, made March 15, 1847.) The announcement of this †double discovery, by Leverrier, to the French Academy, Comptes Rendus, 1847, March 29—the presentation by Captain Lalande, of the Manuscripts of the Histoire Céleste to Arago—his donation of them to the Royal Observa-

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* Comptes Rendus, 1847, April 19th.

† If I have rightly interpreted the papers relative to the discovery made by Dr. Petersen, it seems that this distinguished astronomer pursued the plan which I had originally proposed to pursue, and in fact had actually commenced, of making a trial catalogue, and then observing the heavens for the purpose of finding what stars are now missing.

If I was able to effect my purpose without the use of the telescope, except for confirmation, and not for discovery, I was perhaps indebted to the more extensive series of observations, European and American, which had been discussed, and which enabled me to restrict the limits of Neptune's place in 1795, more than could be done by Encke's Elements, used by Dr. Petersen, and based on a far shorter period of observations.

tory, Mauvais' critical examination of them, and detection of the other suppressed observation of May 8—the surprising confirmation of the truth and of the excellence of the two observations, by the perfect representation of the computed two days' motion of the planet—all these facts have, through other channels, been made matters of history.

SECTION 3.

COMPUTATIONS CONFIRMING THE AUTHENTICITY OF LALANDE'S PRINTED OBSERVATIONS.

No. 33. In order to confirm or set aside this hypothesis of the Lalande observation, I employed my leisure from professional duties in the completion of the plan originally proposed to myself, of inserting in the equations of condition a term depending on the daily variation of the radius vector, subject to the equable description of areas.

For this purpose I computed new Disturbed Elements IV from the normal places of September 28th and December 27th, already given, using for the constant radius vector the value in Elements II.

ELEMENTS IV.—DISTURBED ELLIPSE.

$$\left.\begin{aligned}\pi &= \text{unknown.}\\ \Omega &= 129^\circ\ 51'\ 13''.50\end{aligned}\right\}\ \text{m. eq. Jan. 1, 1847.}$$

$$\begin{aligned}
i &= 1\ 45\ 35\ .66\\
e &= \text{unknown.}\\
\mu &= 21''.416035\\
\varepsilon &= \text{unknown.}\\
T &= 165^{y}\tfrac{6883}{10000}\\
\pi + v = \omega &= 327^\circ\ 34'\ 19''.03\ \text{m. noon, Jan. 1, 1847.}
\end{aligned}$$

From these elements I computed an Ephemeris IV of Neptune, and compared with it all the observations received, from August 4th, 1846, to April 30th, 1847. This list of observations amounts to 113 American, and 366 European. The discussion of all the direct meridian observations of Neptune gave the following normal corrections of Ephemeris IV, in R. A. and Dec.:

Date.			Δ A	Δ D
1847.	Sept.	28,	+ 0″.3	— 0″.6
"	Oct.	8,	+ 0 .4	— 0 .6
"	"	18,	+ 0 .4	— 0 .6
"	"	28,	+ 0 .2	— 0 .5
"	Nov.	7,	+ 0 .0	— 0 .8
"	"	17,	+ 0 .2	— 1 .1
"	"	27,	+ 0 .3	— 1 .0
"	Dec.	7,	+ 0 .7	— 1 .0

With these values were determined the normal places of the four principal stars used for comparison in the equatorial instruments, by a discussion of all the equatorial measures in the Astron. Nachr. to No. 591 inclusive, and in the proceedings of the Royal Astronomical Society, and in the United States. The mean places of these stars for January 1st, 1847, thus obtained, are as follows:

a =	327°	32′	16″.71	a' =	— 13°	23′	39″.44	
b =	327	57	42 .75	b' =	— 13	25	57 .75	
c =	328	2	25 .95	c' =	— 13	35	4 .23	
d =	329	48	55 .93	d' =	— 13	15	16 .39	
To these add 38 Aquarii =	330	36	38 .55	=	— 12	18	52 .04	from B. A. C.

With these places* of the stars used for comparison, all the equatorial measures were reduced to observed places of Neptune; and then XIII normal places were formed from a combination of 479 observations. These normal places, with the correction of Ephemeris V from Disturbed Elements V, are here appended. The places are Right Ascensions and Declinations of Neptune, referred, as before, to the mean equinox of January 1st, 1847, corrected for parallax, but not for planetary aberration. The corrections $\Delta\lambda$ and $\Delta\beta$ are those of the heliocentric longitude and latitude.

SECOND GEOCENTRIC NORMAL PLACES OF NEPTUNE.

No.	Date. Mean noon Green'h.			♆ Obs. R. A. A′.			Weight.	♆ Obs. Dec. D′.			Weight.	Correction of the heliocentric places. Obs.—Eph. V. Δ λ	Obs.—Eph. V. Δ β
				°	′	″		°	′	″		″	″
I.	1846.	Aug.	9	329	26	49.17	2.0	— 13	0	6.97	2.0	— 0.22	— 0.72
II.	"	Sept.	28	328	13	44.17	24.7	— 13	26	13.51	24.5	+ 0.08	+ 0.37
III.	"	Oct.	8	328	3	31.66	62.0	— 13	29	45.57	66.2	+ 0.17	+ 0.28
IV.	"	"	18	327	55	56.59	43.4	— 13	32	21.64	39.3	— 0.06	+ 0.09
V.	"	"	28	327	51	17.81	68.6	— 13	33	54.50	65.0	— 0.20	+ 0.71
VI.	"	Nov.	7	327	49	50.22	80.2	— 13	34	21.63	74.2	— 0.13	— 0.42
VII.	"	"	17	327	51	39.64	61.5	— 13	33	38.79	54.8	+ 0.25	— 0.27
VIII.	"	"	27	327	56	47.94	33.0	— 13	31	45.60	26.1	— 0.25	— 0.05
IX.	"	Dec.	7	328	5	10.16	36.1	— 13	27	46.67	36.4	— 0.49	— 0.08
X.	"	"	17	328	16	35.10	34.0	— 13	24	42.99	32.6	+ 0.29	+ 0.25
XI.	"	"	27	328	30	46.26	13.6	— 13	19	41.49	15.0	+ 0.13	+ 0.33
XII.	1847.	Jan.	16	329	6	0.48	18.1	— 13	7	15.48	23.1	+ 0.34	— 0.93
XIII.	"	April	6	331	49	47.18	25.	— 12	9	17.28	18.	— 0.10	+ 0.65

* The correction of the places of the first two stars, as used in Section 2, are, respectively,

$$d\,a = -0''.08 \quad , \quad d\,a' = -0''.27$$
$$d\,b = -0\ .06 \quad , \quad d\,b' = -0\ .53$$

Elements V were deduced from Elements IV by the following process, which is, perhaps, a new application of the method of mechanical quadratures to the direct computation of a disturbed orbit from observations. The conditional equation has the form,

$$\sigma = a\,x + b\,y + c\,z + d\,u + e\,v + \&c. + n$$

In which,

$$a = (t - 146 \text{ years } 340 \text{ days}) \text{ mean time Greenwich.}$$
$$b = 1$$
$$c = \frac{d\,\omega}{d\,r}$$
$$d = \left(a\,c - \frac{2\,n_0}{r_0} \times A^{(a)}\right)$$
$$e = \left(a^2\,c - \frac{2\,n_0}{r_0} \times B^{(a)}\right)$$
$$n = \left(\omega_{\prime}^{(a)} - \omega^{\prime(a)}\right) = \text{computed less observed true orbital longitude.}$$

Also,

n_0 = the assumed true sidereal daily angular motion , for $a = o$
ω_0 = " " orbital longitude , "
r_0 = " " radius vector , "
x, y, and z $= \Delta\,n_0\;,\;\Delta\,\omega_0\;,\;\Delta\,r_0 =$ the required corrections
$\omega_{\prime}^{(a)}$ = value of ω for date t, from normal place, using $r = r_0$
$\omega^{\prime(a)} = \omega_0 + a\,n_0$
$r^{(a)} = r_0 + z + a\,u + a^2 v + \&c.$
$K^2 = (r_0 + z)^2\,(n_0 + x) =$ Neptune's daily area.
$n^{(a)} = K^2 \left(r^{(a)}\right)^{-2}\; 2 =$ value of n for conservation of areas.

$A^{(a)}$, $B^{(a)}$, &c. = the part of the co-efficients of u and v, introduced by quadratures.

These co-efficients were computed by Laplace's formula for mechanical quadratures, Mec. Cel. V, p. 207. The corrections of the residual errors are stated above. The XIII conditional equations were

						″
I	, 0 =	− 0.6 × x	+ 0.5 × y	− 0.213 × z	+ 0.015 × u	− 0.35
II	, 0 =	− 0.7	+ 1.	+ 1.444	− 0.216	− 0.19
III	, 0 =	− 0.6	+ 1.	+ 1.728	− 0.212	− 0.13
IV	, 0 =	− 0.5	+ 1.	+ 1.954	− 0.199	+ 0.24
V	, 0 =	− 0.4	+ 1.	+ 2.121	− 0.172	+ 0.51
VI	, 0 =	− 0.3	+ 1.	+ 2.228	− 0.135	+ 0.57
VII	, 0 =	− 0.2	+ 1.	+ 2.266	− 0.091	+ 0.29
VIII	, 0 =	− 0.1	+ 1.	+ 2.210	− 0.044	+ 0.88
IX	, 0 =	+ 0.0	+ 1.	+ 2.112	+ 0.000	+ 1.20
X	, 0 =	+ 0.1	+ 1.	+ 1.994	+ 0.040	+ 0.49
XI	, 0 =	+ 0.2	+ 1.	+ 1.731	+ 0.070	+ 0.68
XII	, 0 =	+ 0.4	+ 1.	+ 1.149	+ 0.094	+ 0.54
XIII	, 0 =	+ 1.2	+ 1.	− 1.696	− 4.050	+ 0.20

and the normal equations,

$$
\begin{array}{llllll}
0 = & +3.41 \times x & -\ 1.200 \times y & -\ 6.117 \times z & -\ 4.825 \times u & +0''.415 \\
0 = & -1.20 & +12.250 & +19.131 & -\ 4.929 & +5.105 \\
0 = & -6.12 & +19.131 & +44.045 & +\ 5.143 & +9.967 \\
0 = & -4.83 & -\ 4.929 & +\ 5.143 & +16.651 & -0.920
\end{array}
$$

whence,

$$
\begin{array}{lll}
x = -0.902\ 267 & \Delta\, n_0 = -0''.009\ 02267 & \Sigma\, \varepsilon\varepsilon = 0''.75 \\
y = -0.251\ 045 & \Delta\, \omega_0 = -0.251 & 0.674 \sqrt{\dfrac{\Sigma\, \varepsilon\varepsilon}{(n-1)}} = \pm 0.25 \\
z = -0.217\ 643 & \Delta\, r_0 = -0.002\ 176425 & \\
u = -0.213\ 290 & \Delta_t\, r = -0.000\ 0042658 &
\end{array}
$$

and from these values,

$$
\begin{array}{lll}
\text{August 9, 1846,} & r = 30.003\ 3995 ; & \omega = 326^\circ\ 42'\ 1''.328 \\
\text{April 6, 1847,} & r' = 30.002\ 3757 ; & \omega' = 328\ \ 8\ 35.249
\end{array}
$$

These quantities, by Gauss' method, gave π and e. The further rectification of the values of $\Delta\, \Omega$ and $\Delta\, i$ gave the XIII conditional equations:

					Residual $\Delta\, D_l$ Elements V.
				$''$	$''$
I	$0 = -0.0311 \times d\,\Omega$	$+ 0.307 \times d\,i$	$- 1.48$	;	$- 0.72$
II	$0 = -0.0302$	$+ 0.303$	$- 0.38$	;	$+ 0.37$
III	$0 = -0.0300$	$+ 0.303$	$- 0.47$	;	$+ 0.28$
IV	$0 = -0.0299$	$+ 0.302$	$- 0.66$	;	$+ 0.09$
V	$0 = -0.0297$	$+ 0.302$	$- 0.04$	;	$+ 0.71$
VI	$0 = -0.0295$	$+ 0.301$	$- 1.17$	;	$- 0.42$
VII	$0 = -0.0293$	$+ 0.300$	$- 1.02$	;	$- 0.27$
VIII	$0 = -0.0292$	$+ 0.300$	$- 0.80$	;	$- 0.05$
IX	$0 = -0.0289$	$+ 0.298$	$- 0.83$	;	$- 0.08$
X	$0 = -0.0288$	$+ 0.298$	$- 0.50$	;	$+ 0.25$
XI	$0 = -0.0287$	$+ 0.298$	$- 0.42$	;	$+ 0.33$
XII	$0 = -0.0285$	$+ 0.298$	$- 1.68$	;	$- 0.93$
XIII	$0 = -0.0288$	$+ 0.309$	$- 0.10$	;	$+ 0.65$

Their solution gave

$$\Delta\, i = 2''.49 + 0.10 \times \Delta\, \Omega$$

In which the value of $\Delta\, \Omega$ is arbitrary; and being made $= 0$, gives $\Delta\, i = 2''.49$.

Elements V. were then formed from Elements IV, by applying the values of $\Delta\, i$ and $\Delta\, \Omega$ thus obtained, and by deducing the numerical values of π, M, e, a, μ, T, by Gauss' method, from the two values of r and ω, for August 9, 1846, and April 6, 1846.

DISTURBED ELEMENTS V.

$$
\begin{array}{ll}
\pi = & 348^\circ\ 27'\ 46''.18 \\
\Omega = & 129\ \ 51\ \ 13\ .53
\end{array}
\Bigg\}\ \text{m. eq. January 1, 1848.}
$$

$$
\begin{array}{ll}
i = & 1\ \ 45\ \ 38\ .10 \\
e = & 0.0050529 \\
\mu = & 21.43784 \\
\mathrm{M} = & 327^\circ\ 07'\ 20''.52 \\
\mathrm{T} = & 165.\frac{5133}{10000}
\end{array}
$$

No. 35. By using in the solution, instead of Gauss' k, an analogous quantity for the actual position of the disturbing bodies of the system for the middle data, viz., $k' = 3545.489$, there would result the following values of three of these elements:

$$
\begin{array}{ll}
\mu = & 21''.411\ 44 \\
a = & 30\ .17775 \\
\mathrm{T} = & 165.\frac{7175}{10000}
\end{array}
$$

which might be taken as the first rough approximation towards the elliptic Elements of Neptune. The Ephemeris from the last values, with the remaining Disturbed Elements *V, without attending to perturbations, agreed with the heavens in May, 1795, within about half a degree, and having the Lalande star, supposed to be Neptune, almost directly in its path. It would be necessary to compute the perturbations of the planets for the time, from August 4th to April 6th, in order to push the approximation farther. This small difference was all that stood in the way of the confirmation of the discovery, previous to the arrival of the news of the Mauvais discovery of the other Lalande observation.

SECTION 4.

SUBSEQUENT RESEARCHES ON THE ORBIT OF NEPTUNE.

No. 36. The †news of this most fortunate discovery of another Lalande observation, and confirmation of the former, reached Washington, May 19, 1847, under circumstances calculated to leave no doubt of the certainty of the facts, and relieved me from the necessity of further discussion of the probable evidence in the case. I had already commenced the computation of the Laplacian constants for the perturbations of Neptune; but my professional

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* In some of the earlier partial publications of these researches, an oversight was committed in completing Elements V. This is here corrected. The correction is of little importance except for the purpose of truth, as these corrected Elements are superseded by those of Sec. IV.—S. C. W.

† Comptes Rendus, April 19, 1847.

labors for the U. S. Coast Survey did not allow sufficient leisure for completing the task with the requisite despatch. I therefore deferred it to a future day, and availed myself of the kind offer of Prof. Peirce to furnish me in due season with an Ephemeris of the perturbations of Neptune by all the other planets. Prof. Peirce's first Ephemeris of these perturbations was communicated to me in November, 1847. The year of Neptune, assumed as the basis of Prof. Peirce's computations, was double of that of Uranus, and the eccentricity of Neptune's orbit was omitted.

No. 37. Being now in a condition, through the friendly communication of Prof. Peirce, to resume the research with better prospect of success, I extended the Ephemeris of Neptune, in R. A. and Dec., from the 30th of April, 1847, to the 1st of February, 1848, and compared with it all the European and American observations received to the 1st of December, 1847. In this manner were obtained the following normal corrections of the Ephemeris from Elements IV, in R. A. and Dec.

THIRD GEOCENTRIC NORMAL PLACES OF NEPTUNE.

	Obs.—Eph. IV. Δ A	No. Obs.	Obs.—Eph. IV. Δ D	No. Obs.	Instrument.
	$''$		$''$		
1847, April 6	— 1.65	27	— 0.67	41	Equatorial.
May 9	— 3.52	20	— 2.98	30	"
June 1	— 0.30	5	— 4.16	10	"
June 23	— 7.63	12	— 5.53	20	"
July 8	— 6.73	5	— 5.96	10	Mer. & Eq.
July 31	— 5.93	17	— 5.52	15	"
Aug. 12	— 6.99	12	— 5.50	11	"
Aug. 22	— 7.65	19	— 6.58	19	"
Sept. 7	— 7.33	4	— 5.83	4	"
Sept. 18	— 8.24	3	— 6.09	8	"
Sept. 27	— 11.77	3	— 7.07	3	"
Oct. 4	— 10.33	2	— 7.08	2	"

By extending Ephemeris IV, corrected by the normal places, back to August 20, I derived an estimated opposition for 1846. That of August 22 served for 1847. By means of the two, there was found the correction of the angular motion of Neptune by Ephemeris IV, from August 20, 1846, to August 22, 1847, that is, for a synodic year. Also, a value was obtained for the synodic year from September 26, 1846, to September 28, 1847. In both instances, the effect of change of the relative perturbations from Prof. Peirce's 1st Ephemeris was taken into account. The results are, for the true average daily sidereal motion:

	Ephemeris from Elements IV . . .	$\nu = 21''.64548$
(A)	By the two oppositions, 1847, April 30,	$\nu = 21.62637$
(B)	By the two normal places	$\nu = 21.60833$
	Mean of (A) and (B) adopted . . .	$\nu = 21.61735$

No. 38. The five normal places selected as the basis of the first approximation to the elliptic elements of Neptune were reduced to geocentric latitudes and longitudes, then to heliocentric longitudes and latitudes, by assumed values of r and of sec. ($\beta =$ the hel. lat.,) with coefficients for $d\,r$. That of sec. β is well enough known. The values of $\delta\,v$ and $\delta\,r$, in Prof. Peirce's 1st *Ephemeris, were applied inversely to obtain the elliptic heliocentric longitudes and latitudes. The new values of the ☊ and i were derived from the two extreme normal places; hence were obtained the following data for ω', or the true longitude on the orbit:

FIRST HELIOCENTRIC NORMAL PLACES.

$$\begin{array}{llll}
\text{I} ; t_1 = \text{Jan. 1, 1847} - 18864^d & = \text{May } 9,\ 1795 & ; \omega_1 = 215^\circ\ 48'\ 7''.68 - & 44''.1\ (r_1 - 30.28778) \\
\text{II} ; t_2 = \qquad\qquad - 134 & = \text{Aug. } 20,\ 1846 & ; \omega_2 = 326\ 45\ 30.83 - & 1.2\ (r_2 - 29.99256) \\
\text{III} ; t_3 = \qquad\qquad - 55 & = \text{Nov. } 7,\ 1846 & ; \omega_3 = 327\ 13\ 58.57 - & 227.6\ (r_3 - 29.99256) \\
\text{IV} ; t_4 = \qquad\qquad + 95 & = \text{April } 6,\ 1847 & ; \omega_4 = 328\ 8\ 0.67 + & 163.8\ (r_4 - 29.99256) \\
\text{V} ; t_5 = \qquad\qquad + 233 & = \text{Aug. } 22,\ 1847 & ; \omega_5 = 328\ 57\ 44.39 + & 1.0\ (r_5 - 29.99256)
\end{array}$$

The value 29.99256, for the last four dates, was that value which for $d\,r = o$ would give $\frac{\omega_4 - \omega_3}{t_4 - t_3} = \nu = 21''.61735$. The formula $\frac{1}{a} = \left(\frac{2}{r} - \frac{r\,r\,\nu\,\nu}{k\,k}\right)$, gives for these values of r and ν, the results $\mu, = 21''.55448$, $a = 30.03634$, $\mathrm{T} = 164\,\frac{6181}{10000} =$ period in tropical years.

No. 39. This value of μ is a deduction from direct observation, and has in it no other source of theoretical error than that which arises from the change of the radius vector in 150 days, and from the change of ν in the interval of 88 days from April 30, 1847, backwards, to Jan. 20. In order to estimate this source of error, I shall here anticipate results not known in this stage of the inquiry. We have, by Elliptic Elements I, the values

$$\Delta_t\,v = -\,0''.0000271$$
$$\Delta_t\,\nu = +\,0''.0000335$$

The small modification of μ derived from the use of these small corrections, was not found, on subsequent trial, to give better elements than the above value of $\mu = 21''.55448$. After making several approximations towards the Elliptic Elements, the radius vector was found to diminish from 29.99256, January 20, 1847, to 29.98676, August 22, of that year. Hence, the fundamental quantities for making the approximations towards the true value of the elements, are,

$$\begin{array}{ll}
\text{May } 9,\ 1795,\ \pi + v_1 = \omega_1 = 215^\circ\ 48'\ 7''.68 - 44''.1\ (r_1 - 30.28778) \\
\text{August } 22,\ 1847,\ \pi + v_5 = \omega_5 = 328\ 57\ 44.39 + 1.0\ (r_5 - 29.98676) \\
\mu = 21.55448
\end{array}$$

* See Proceedings R. A. S., Vol. VIII, p. 40.

By expressing the true anomaly in terms of the mean and of the ascending powers of the eccentricity, a direct solution of the problem may be obtained. Such a formula was communicated to me by Prof. Peirce. I found, however, that the method of trial and error, with an assumed value of the angle of eccentricity φ, was very convenient in practice. The partial *differential,

$$\left(\frac{d\,[(M^1 - M) - (v^1 - v)]}{d\,\varphi}\right) = -\,0.303$$

afforded a ready convergence from an assumed to the true value of φ, whence π and ε were derived.

The exact solution completed the Elliptic Elements I of Neptune, as follows:

$$\left.\begin{aligned}\pi &= 48^\circ\ 21'\ 2''.93\\ \Omega &= 130\ \ 4\ \ 35.03\end{aligned}\right\}\text{M. Eq., Jan. 1, 1847.}$$

$i = 1\ 46\ 59.54$

$e = 0.00857741$

$\mu = 21''.55448$

$\varepsilon = 328^\circ\ 31'\ 56''.36$ M. noon Green., Jan. 1, 1847.

$T = 164\frac{6181}{10000}$ Trop. years

No. 40. The star e'' Aquarii, on which the IVth normal place rests, has since been found to require a correction of the value of British Association Catalogue, of — 1″.81 in R. A., and of — 3″.00 in Dec. Applying these values, this first approximation towards the Elliptic Elements furnished the following comparison between theory and observation in R. A. and Dec., using Prof. Peirce's first values of the perturbations, $\delta\,v$ and $\delta\,r$:

		Obs.—Eph. Δ A	Obs.—Eph. Δ D
I	May 9, 1795,	+ 1.86	— 1.30
III		— 2.99	— 1.23
IV		— 1.00	— 0.40
V		— 0.24	+ 0.00

This result, without the correction of the catalogue, was published in the January number of Silliman's Journal for 1848. It was also communicated to the American Academy of Arts and Sciences by Prof. Peirce, in December, 1847. In the same Memoir, Prof. Peirce gives the perturbations of Neptune by all the planets, computed to the hundredth of a second, "including all sensible terms to the cube of the eccentricities." The basis of this computation was the Elliptic Elements I, last mentioned. It was the opinion of Prof. Peirce and myself that they were sufficiently precise to form the ground-work of the full development of the theory of Neptune. It will be seen from the

* M is the mean and v the true anomaly in 1795, May 9. The accented quantities are for August 22, 1847. φ is the angle of eccentricity.

sequel that the new discussion of these Elements, with the corrected Ephemeris of the values of the perturbations $\delta\, v$ and $\delta\, r$, which are given from October, 1846, to January, 1851, by that eminent astronomer, together with the value for May 9, 1795, has indicated only slight modifications of the first approximation towards the Elliptic Elements.

No. 41. Although the discrepancy between theory and observation for Elliptic Elements I was small, yet the modification of the values of $\delta\, v$, and $\delta\, r$, rendered a small correction of them necessary. Wishing to leave nothing undone towards a complete discussion of the theory of Neptune, as far as circumstances permitted, I resumed the study, and reduced the observations extant to the 1st of February, 1848, and compared them with the Ephemeris from Disturbed Elements IV, already referred to.

The four fundamental places derived from this discussion were:

SECOND HELIOCENTRIC NORMAL PLACES.

					°	′	″	″	
I	1795, May 9,	28374	;	$\omega_1 =$	215	48	3.99 —	44.1	$\times\, (r_1 - 30.27717)$
II	1846, Nov. 7,	82831	;	$\omega_2 =$	327	14	1.39 —	227.6	$\times\, (r_2 - 29.98530)$
III	1847, April 6,	82321	;	$\omega_3 =$	328	7	57.92 +	163.8	$\times\, (r_3 - 29.98530)$
IV	1849, Aug. 22,	83294	;	$\omega_4 =$	328	57	45.52 +	1.0	$\times\, (r_4 - 29.98530)$

where ω is the true longitude on the orbit, and r the elliptic portion of the radius vector. A new discussion of the value of the disturbed radius vector, and daily angular motion for the middle date between II and III, by the process of No. 38, indicated no change in the mean motion of Elliptic Elements I.

It was only necessary to assume a value of the elliptic portion of the radius vector for the last place IV, and then by the subsidiary equation of No. 39, to converge to the remaining elements, which must perfectly represent places I and IV. The elements so found were tested by comparison of the Ephemeris which they gave with observed normal Right Ascensions and Declinations of 1846, November 7; 1847, April 6 and November 16. If the representation was not satisfactory, a new trial radius vector for August 22, 1847, was selected, and the converging and testing process repeated. Several repetitions resulted at last in the following values, which I have called Elliptic *Elements II of Neptune:

The corrections of Elliptic Elements I from these last computations were, respectively,

$$\begin{aligned}
d\,\pi &= -\ 1^\circ\ 8'\ 56''.43 \\
d\,\Omega &= -\ 14''.22 \\
d\,i &= -\ 0''.57 \\
d\,e &= +\ 0.00014205 \\
d\,\mu &= 0''.00 \\
d\,\mathrm{M} &= +\ 47''.84 \\
d\,\mathrm{T} &= 0^{\mathrm{y}}.0
\end{aligned}$$

* See Appendix No. I to Volume II, Smithsonian Contributions. See, also, my letter of March 6, 1848, to Prof. Peirce. Proceedings, A. A. A. S. for April 4, 1848, where $d\,e$ is erroneously printed $= 0.000014205$.

Whence, for Elliptic Elements II,

$$
\begin{array}{lll}
\pi = & 47^\circ\ 12'\ 6''.50 & \rbrace \text{mean equinox of Jan. 1, 1847.} \\
\Omega = & 130\ \ 4\ 20.81 & \\
i = & 1\ 46\ 58.97 & \\
e = & 0.00871946 & \\
\mu = & 21''.55448 & \\
\varepsilon = & 328^\circ\ 32'\ 44''.20 & \text{mean noon, Jan. 1, 1847.} \\
T = & 164\ .6181 & \text{tropical years.}
\end{array}
$$

No. 42. I subjoin the corrections of this Ephemeris as indicated by the eight day groups of meridian observations, viz., for the date and for the preceding three and following four days. In forming these normal corrections, I have rejected all results which differed 6″ or more from the mean, believing that their use would diminish rather than increase the precision of the final result. Equal weights have been given to those which were retained. In this list no observation is used twice.

FOURTH GEOCENTRIC NORMAL PLACES. EIGHT DAY GROUPS.

CORRECTION OF THE PRECEDING EPHEMERIS, FROM MERIDIAN OBSERVATIONS ONLY.

Date, mean time, Greenwich.	Obs.—Eph. Δ A	No. Obs.	Obs.—Eph. Δ D	No. Obs.
1846, Sept. 26ᵈ.5	— 0″.17	9	+ 0″.55	9
" Oct. 4 .5	— .67	23	— .03	20
" " 12 .5	— .14	39	+ .31	33
" " 20 .5	— .18	23	+ .54	20
" " 28 .5	+ .72	23	+ 1.10	17
" Nov. 5 .5	+ .75	43	+ .98	35
" " 13 .5	+ .08	46	+ .41	37
" " 21 .5	+ .26	21	+ .72	18
" " 29 .5	— .16	24	+ .86	20
" Dec. 7 .5	— .59	13	+ .77	12
1847, July 27 .5	— .09	9	+ .33	8
" Aug. 4 .5	— .22	6	— .48	7
" " 12 .5	— .85	16	+ .35	14
" " 20 .5	— 1.27	11	— .13	13
" " 28 .5	— .93	8	+ .13	8
" Sept. 5 .5	— .99	10	+ .83	9
" " 13 .5	— .82	8	+ .83	7
" " 21 .5	+ .12	9	+ .05	8
" " 29 .5	— 1.29	7	+ .15	5
" Oct. 7 .5	— 1.03	4	+ 1.98	4
" " 15 .5	— 0.80	10	+ .55	10
" " 23 .5	— .95	10	— .16	6
" " 31 .5	+ 1.67	8	+ .71	8
" Nov. 8 .5	+ .74	6	+ 1.51	9
" " 16 .5	+ 1.61	6	+ 1.08	4
" " 24 .5	— 1.23	9	+ .53	7
" Dec. 2 .5	+ .36	3	+ 1.60	2
" " 10 .5	— .78	4	+ .67	3
" " 18 .5	+ 0.98	3	— .05	3

No. 43. The eight day groups of No. 42 have been further grouped together, according to their weights, by extending the interval, before and after the date, to 27 and 28 days respectively. The following list contains the groups. For the interval of 56 days, each observation is used seven times in seven consecutive groups.

FIFTH GEOCENTRIC NORMAL PLACES. FIFTY-SIX DAY GROUPS.

CORRECTION OF THE PRECEDING EPHEMERIS, FROM MERIDIAN OBSERVATIONS ONLY.

Date.	Obs.—Eph. R. A.	No. Obs.	Obs.—Eph. Dec.	No. Obs.
1846, Sept. 26	— 0″.28	94	+ 0″.31	82
" Oct. 4	— .09	117	+ .45	99
" " 12	+ .14	160	+ .58	134
" " 20	+ .12	208	+ .55	171
" " 28	+ .15	218	+ .56	180
" Nov. 5	+ .20	219	+ .66	180
" " 13	+ .22	193	+ .74	159
" " 21	+ .27	170	+ .77	139
" " 29	+ .20	147	+ .73	122
" Dec. 7	— .23	104	+ .63	87
1847, July 27	— .58	42	+ .16	39
" Aug. 4	— .63	50	+ .16	47
" " 12	— .68	60	+ .16	54
" " 20	— .72	65	+ .19	60
" " 28	— .87	59	+ .37	52
" Sept. 5	— .71	52	+ .32	64
" " 13	— .78	56	+ .46	60
" " 21	— .66	49	+ .52	55
" " 29	— .71	40	+ .42	47
" Oct. 7	— .89	55	+ .47	46
" " 15	— .81	55	+ .67	55
" " 23	— .92	61	+ .81	53
" " 31	— .91	53	+ .90	54
" Nov. 8	— .91	36	+ .77	49
" " 16	— .66	41	+ .81	35
" " 24	— .44	37	+ .98	36
" Dec. 2	— .07	27	+ .85	22
" " 10	— .02	22	+ .62	17
" " 18	— .53	13	+ .48	13

No. 44. By means of the normal Ephemeris obtained by applying the corrections of No. 43, Neptune's place has been used to determine the normal mean places, for January 1, 1847, of the fixed stars, which have been compared with Neptune in the equatorial instruments provided with filar-micrometers. I subjoin the list of these eleven stars, from a to l inclusive, with the final authorities for their mean places. The same principle of rejection of results differing 6″ from the mean has been continued. Equal weights are given to those retained. I am aware that some of the instruments and observers were

entitled to greater weight than others; but it would have been a delicate matter to discriminate where all is excellent. Also each night's work, without reference to the number of measures, has a unit of weight. It may be presumed that the number has been deemed sufficient to exhaust very nearly the accidental error of seeing and hearing, in relation to the wires and clock.

Authorities for ⁎ a, 7th Mag., (7648 B. A. C.)

		° ′ ″	Measures.		° ′ ″	Measures.
1847. Jan. 1, concluded	$a =$	327 32 16.88	846	$a' = -$	13 23 39.72	485
By Cambr'e Equatorial, E.,	$d\,a_0 = -$	1.65	70	$d\,a'_0 = -$	0.75	58
By " " Mass.	$= -$	0.88	73	$= +$	2.38	71
By Christiania Mer.,	$= +$	1.10	25			
By Durham Equatorial,	$= +$	0.55	174	$= -$	1.05	62
By Konigsberg Heliometer,	$= -$	0.34	26	$= -$	1.63	26
By Makerstoun Equatorial,	$= +$	0.67	130	$= +$	0.37	61
By Naples "	$= -$	1.00	84	$= +$	0.19	84
By Washington "	$= -$	0.53	248	$= -$	0.04	103
By Wrottesley's "	$= -$	1.03	16	$= +$	0.73	20

Authorities for ⁎ b, 9th Mag.

		° ′ ″	Measures.		° ′ ″	Measures.
1847. Jan. 1, concluded	$b =$	327 57 42.19	426	$b' = -$	13 25 57.65	366
By Berlin Equatorial,	$d\,b_0 = +$	0.10	250	$d\,b'_0 = -$	0.54	240
By Kasan "	$= +$	0.48	8	$= +$	3.82	4
By Konigsberg Heliometer	$= +$	0.16	16	$= +$	0.42	16
By London Equatorial,	$= -$	0.31	12	$= -$	1.28	12
By Pulkova, "	$= -$	1.09	40	$= +$	0.53	40
By Washington "	$= +$	0.78	100	$= +$	0.79	54

Authorities for ⁎ c, 9th Mag.

		° ′ ″	Measures.		° ′ ″	Measures.
1847. Jan. 1, concluded	$c =$	328 2 25.67	181	$c' = -$	13 35 4.05	112
By Berlin Equatorial,	$d\,c_0 = +$	0.49	45	$d\,c'_0 = +$	1.58	45
By Casan "	$= -$	1.58	18	$= +$	0.18	4
By Konigsberg Heliometer,	$= -$	0.83	20	$= -$	0.63	20
By Pulkova Equatorial,	$= -$	0.43	10	$= -$	1.06	10
By Venice Meridian,	$= -$	0.19	25			
By Washington Equatorial,	$= +$	0.80	63	$= -$	0.33	30
By " Meridian,		.		$= -$	0.05	3

Authorities for ⁎ d, 9th Mag.

		° ′ ″	Measures.		° ′ ″	Measures.
By Washington Equatorial,	$d_0 = a_0 +$	2 6 38.51	42	$d'_0 = a'_0 +$	0 0 22.91	18
By " "	$d_0 = b_0 +$	1 41 16.03	23	$d'_0 = b'_0 +$	0 10 41.60	11
1847. Jan. 1, concluded	$d =$	329 48 56.76	65	$d' =$	— 13 15 16.43	29

Authorities for ∗ *e, 9th Mag.*

		Measures.		Measures.
1847. Jan. 1. Konigs'g Heliometer,	$e_0 = 328° 12' 30''84$	74	$e'_0 = -13° 45' 18''43$	74

Authorities for ∗ $f = e''$ *Aquarii, 7th Mag.*

		° ′ ″	Measures.		° ′ ″	Measures.
1847. Jan. 1, concluded	$f =$	330 36 36.74	189	$f' = -$	12 18 55.04	111
By Cambridge (Mass.) Equatorial,	$df_0 = -$	1.83	28	$df'_0 = -$	0.07	28
By Durham Equatorial,	$= +$	0.29	69	$= -$	0.90	67
By Philadelphia Equatorial,	$= +$	1.51	50	$= +$	0.65	12
By direct Meridian Obs.,	$= +$	0.01	42	$= -$	0.62	4

Authorities for ∗ $g =$ 7740 B. A. C., *7th Mag.*

		° ′ ″	Measures.		° ′ ″	Measures.
1847. Jan. 1, concluded	$g =$	331 1 51.92	82	$g' = -$	11 49 8.46	61
By Durham Equatorial,	$dg_0 = +$	0.79	61	$+$	0.00	61
By Meridian Obs.,	$= +$	2.72	21			

			° ′ ″	Measures.		° ′ ″	Measures.
1847. Jan. 1.	By Konigs'g Heliometer,	∗ $h =$	331 18 49.11	3	$h' = -$	12 40 48.88	3
"	" "	∗ $i =$	330 5 39.19	3	$i' = -$	12 21 32.22	3
"	" "	∗ $k =$	330 31 0.19	4	$k' = -$	13 5 9.58	4
"	" "	∗ $l =$	330 28 47.89	2	$l' = -$	13 9 31.48	2

No. 45. The other stars used for comparison with Neptune in the equatorial instruments, have not been determined with sufficient precision to add to the weight of the normal places furnished by the meridian observations, and by the comparisons with these eleven stars. In many instances I have been compelled to reduce the Cambridge (England) and Hamburg equatorial observations in the same manner as meridian observations, where several stars have been used, whose names, or weights, or authorities, for mean places are not mentioned. Their comparison with the Ephemeris is given; but I have not used them in forming the normal Ephemeris, lest the weight of the result should be lessened from the uncertainty concerning the stars' places.

No. 46. The *equatorial observations with these eleven stars were reduced, by bringing them all to the form of differential observations, and then applying the mean places in No. 44. The next step was to form the normal Ephemeris, by repeating the grouping process of Nos. 42 and 43, giving equal weights to a meridian and to an equatorial night's work, without reference to the number of equatorial measures. I subjoin the final correction of the preceding Ephemeris

* In reducing the Washington and Philadelphia equatorial measures, I have applied the small correction for the influence of precession, nutation, and aberration, on the result of the measures after Bessel's formulæ, page 208, of his Astronomische Untersuchungen. I have not applied it to the other measures, presuming that where it was sensible it has been applied by the observers.—S. C. W.

from the discussion of all the observations extant, exclusive of those equatorial measures made with a ring micrometer, or with an undetermined star. The number of days and of observations embraced in each group is 56, having the middle date for the epoch. As far as practicable, each observation has been used the same number of times. This restriction would not apply to the earliest and latest groups of an uninterrupted series.

SIXTH, AND LAST, GEOCENTRIC NORMAL CORRECTIONS OF THE EPHEMERIS, IN FIFTY-SIX DAY GROUPS, HAVING EACH EIGHTH DAY FOR THE MIDDLE DATE.

Date.	Obs.—Eph. R. A.	No. Obs.	Obs.—Eph. Dec.	No. Obs.
1846, Sept. 26	— 0″.21	160	+ 0″.55	144
" Oct. 4	— .11	210	+ .54	188
" " 12	— .29	277	+ .64	244
" " 20	— .26	336	+ .60	293
" " 28	— .20	349	+ .53	304
" Nov. 5	— .11	343	+ .62	297
" " 13	— .04	317	+ .64	273
" " 21	+ .04	305	+ .70	258
" " 29	+ .08	272	+ .75	235
" Dec. 7	+ .34	209	+ .69	179
" " 15	+ .51	168	+ .84	148
" " 23	+ .60	132	+ .95	120
" " 31	+ .95	90	+ .92	80
1847, Jan. 8	+ .79	63	+ .98	50
" April 6	+ .42	15	— .18	16
" July 27	— .49	53	+ .16	50
" Aug. 4	— .59	68	+ .14	65
" " 12	— .58	81	+ .15	75
" " 20	— .64	76	+ .19	71
" " 28	— .76	83	+ .40	76
" Sept. 5	— .61	76	+ .31	83
" " 13	— .58	76	+ .46	80
" " 21	— .71	61	+ .48	67
" " 29	— .73	50	+ .56	57
" Oct. 7	— .95	65	+ .58	57
" " 15	— .85	65	+ .76	67
" " 23	— .94	70	+ .92	61
" " 31	— .95	63	+ .87	65
" Nov. 8	— .96	46	+ .77	51
" " 16	— .74	53	+ .93	48
" " 24	— .56	45	+ .99	45
" Dec. 2	— .24	35	+ .89	30
" " 10	— .09	27	+ .72	22
" " 18	— .44	18	+ .89	18

No. 47. I subjoin the comparison of all the standard observations extant, with the *Ephemeris from Elliptic Elements II, and from Prof. Peirce's Tables

* Appendix I. to Smithsonian Contributions, Vol. II.

of the Perturbations. Each night's work of one observer, with one instrument, counts as one observation. Meridian observations are used, as published by their authors in their most recent works. Equatorial comparisons with either of the stars above referred to, are made to depend upon the following catalogue of mean places, derived from No. 44, and are referred to by the appropriate letter of the star.

Letter.	No. B. A. C.	Mag.	Mean R. A., 1847.0			Mean Dec., 1847.0		
			°	′	″	°	′	″
a	7648	7	327	32	16.88	— 13	23	39.72
b		9	327	57	42.19	— 13	25	57.65
c		9	328	2	25.67	— 13	35	4.05
d		9	329	48	56.76	— 13	15	16 43
e		7, 8	328	12	30.84	— 13	45	18.43
f	7722	7	330	36	36.74	— 12	18	55.04
g	7740	7	331	1	51.92	— 11	49	8.46
h			331	18	49.11	— 12	40	48.88
i			330	5	39.19	— 12	21	32.22
k		8, 9	330	31	0.19	— 13	5	9.58
l			330	28	47.89	— 13	9	31.48

Where several stars are used in furnishing one equatorial observation, without distinguishing the effect of each, it is reduced as published by the observer, without reference to the group of stars, and without being taken into account in forming the normal places. The list which follows, forms, for the interval embraced, the most extensive series of observations yet made on a single planet, and is worthy of the occasion which summoned to active exertion every practical astronomer in the world. With all the pains bestowed upon the computations, some errors may have crept in, for which the author must claim the indulgence of those observers whose works are here brought together in a common field of view.

No. 48. The following *table comprises the observations of 1795, 1845, 1846, and 1847, as compared with the Ephemeris:

* Note by the Secretary, S. I.—The Geneva, Greenwich, Markree, and Oxford observations of 1846, and the Cape of Good Hope, Copenhagen, Christiana, Geneva, Greenwich, Kasan, Kremsmunster, and Petersburg observations, for 1847, having been received by Mr. Walker since the date of his original paper, (April 10th, 1848,) have been reduced by him, and communicated to the Smithsonian Institution. They are now (May, 1850,) inserted in chronological order for facility of comparison. They have not been used in forming the normal places of No. 46; but will hereafter be employed by Mr. Walker, when a further correction of his Elliptic Elements II. shall be needed.—J. H.

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					"		"	
1	1795. May 8	Paris	Mur. Quad.		— 0.29		+ 0.79	
2	10	Paris	"		+ 1.18		+ 0.31	
3	1845. Oct. 25	Munich	Meridian		+ 3.40		+ 2.38	
4	1846. Aug. 4	Cambridge, E.	Equatorial		+ 6.75	1	— 3.38	1
5	12	"	"		— 0.55	1	— 1.68	1
6	Sept. 7	Munich	Meridian		— 6.91		+ 6.26	
7	23	Berlin	Equatorial	*b*	— 2.91	20	+ 0 92	20
8	24	"	"	*b*	— 0.97	14	+ 1.54	14
9	25	"	"	*b*	— 0.58	15	+ 2.16	15
10	26	"	"	*b*	— 0.20	20	+ 0.38	20
11	27	"	"	*a*	+ 3.23	4	+ 2.10	4
12		"	"	*b*	— 0.21	15	+ 0.75	15
13		Gottingen	Meridian		— 1.29		— 1.84	
14		Konigsberg	Heliometer	*e*	— 1.28	4	+ 0.20	4
15	28	Altona	Meridian		— 1.74		— 1.98	
16		Berlin	Equatorial	*b*	— 0.39	15	+ 0.74	15
17		Gottingen	Meridian		+ 6.06		———	
18		Hamburg	"		— 0.54		— 0.78	
19		Konigsberg	Meridian		— 1.48		+ 1.73	
20		"	Heliometer	*e*	— 0.67	10	— 0.11	10
21	29	Altona	Meridian		+ 0.04		+ 1.09	
22		Berlin	Equatorial	*b*	+ 0.91	20	+ 0.87	20
23		Gottingen	Meridian		+ 1.64		———	
24		Hamburg	"		— 3.26		+ 1 31	
25		Konigsberg	"		— 0.19		+ 2.07	
26		"	Heliometer	*e*	— 0.74	8	— 0.26	8
27	30	Bonn	Meridian		+ 0.72		+ 0.97	
28		Konigsberg	Heliometer	*e*	— 1.07	8	— 0.51	8
29		"	Meridian		+ 1.46		+ 0.94	
30	Oct. 1	Altona	"		— 0.08		— 0.55	
31		Hamburg	"		— 3.98		— 4.25	
32	2	Berlin	Equatorial	*b*	+ 0.05	20	+ 0.82	20
33	3	Cambridge, E.	"	*a*	— 0.16		+ 3.21	
34		"	"	*a*	+ 0.49		+ 3.53	
35		Durham	"	*a*	— 6.26	2	———	2
36		Greenwich	Meridian		+ 0.46		+ 1.31	
37		"	Equatorial	*a*	— 0.80	9	+ 2.67	10
38		Konigsberg	Heliometer	*e*	+ 1.92	10	— 0.30	10
39		Liverpool	Meridian		— 6.81		———	
40		Markree	"		+ 4.26		+ 3.42	
41		South Villa	Equatorial	*a*	— 0.51		+ 3.75	
42		Wrottesley	"		— 3.83	8	— 7.00	8
43	4	Altona	Meridian		+ 1.83		+ 1.03	
44		Hamburg	"		+ 2.17		— 2.07	
45		Gottingen	"		+ 0.93		———	
46	5	Altona	"		— 1.19		— 0.73	
47		Cambridge, E.	Equatorial	*a*	+ 0.82		+ 2.13	
48		Greenwich	Meridian		+ 2.60		— 1.89	
49		"	Equatorial	*a*	— 1.43	8	+ 3.52	8
50		Konigsberg	Meridian		+ 0.43		+ 0.64	
51		Kremsmunster	"		+ 2.34		+ 1.60	
52		South Villa	Equatorial	*a*	———		+ 3.51	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					″		″	
53	1846. Oct. 5	Vienna	Equatorial		— 7.26		— 1.85	
54	6	Altona	Meridian		— 0.72		+ 1.20	
55		Berlin	Equatorial	b	+ 0.58	20	+ 0.63	20
56		Geneva	Meridian		— 1.92		— 3.95	
57		Gottingen	"		+ 0.88		+ 1.70	
58		"	"		— 0.82		———	
59		Hamburg	"		— 1.22		— 1.50	
60		Kremsmunster	"		+ 0.89		+ 0.89	
61		Markree	"		+ 2.82		+ 0.69	
62		Oxford	"		+ 2.87		— 2.67	
63		Pulkova	"		———		+ 1.65	
64		Pulkova	"		— 0.37		— 1.02	
65		"	Equatorial	b	— 1.14		+ 1.67	
66		Wrottesley	Meridian		— 0.70		———	
67	7	Greenwich	"		— 0.57		+ 0.27	
68		"	Equatorial	a	+ 1.35	3	+ 2.07	5
69		Konigsberg	Heliometer	e	+ 0.25	8	— 0.41	8
70		Vienna	Meridian		— 0.84		— 1.28	
71	8	Altona	"		+ 0.24		— 2.07	
72		Cambridge, E.	"		— 1.26		+ 2.87	
73		"	Equatorial	a	+ 0.87		+ 2.00	
74		Greenwich	Meridian		— 0.53		+ 0.03	
75		"	Equatorial	a	— 0.07	10	+ 1.02	10
76		Hamburg	Meridian		+ 0.74		+ 0.05	
77		South Villa	Equatorial	b	— 0.62		+ 3.99	
78		Makerstoun	"	a	— 1.27	3	+ 6.96	3
79		Oxford	Meridian		— 1.26		+ 1.06	
80		Turin	"		+ 1.08		+ 5.54	
81		Wrottesley	"		— 1.23		———	
82	9	Bonn	"		+ 1.32		+ 4.06	
83		Geneva	"		— 1.64		— 3.31	
84		Makerstoun	Equatorial	a	+ 0.85	3	+ 1.65	3
85		Konigsberg	Heliometer	e	— 0.07	8	+ 0.15	8
86		Kremsmunster	Meridian		— 2.74		+ 3.51	
87		Vienna	"		— 3.36		+ 1.33	
88	10	Berlin	Equatorial	b	+ 1.07	20	+ 1.45	20
89		Brussells	Meridian		— 0.99		— 0.86	
90		Cambridge, E.	"		———		+ 3.22	
91		Durham	Equatorial	a	+ 2.12	12	———	
92		Geneva	Meridian		+ 0.16		— 1.38	
93		"	Equatorial	a	— 6.35	8	+ 3.11	8
94		Gottingen	Meridian		+ 2.03		+ 4.67	
95		"	"		+ 4.38		———	
96		Greenwich	"		— 0.85		+ 0.76	
97		Liverpool	"		— 4.23		———	
98		Oxford	"		— 0.69		+ 4.26	
99		Pulkova	"		+ 1.52		+ 1.25	
100		"	"		+ 1.52		+ 0.85	
101		"	Equatorial	b	+ 1.91	10	+ 0.64	10
102		Padua	Meridian		+ 0.92		+ 2.17	
103		Turin	"		— 6.32		+ 4.68	
104		Vienna	"		— 3.28		— 3.36	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Mea-sures.	Δ δ	Mea-sures.
					"		"	
105	1846. Oct. 10	Wrottesley	Meridian		— 3.16		———	
106	11	Altona	"		— 0.39		+ 2.01	
107		Hamburg	"		— 3.69		— 2.19	
108		Konigsberg	Heliometer	*c*	— 0.41	8	+ 1.14	8
109		"	"	*b*	— 0.46	4	+ 0.63	4
110		Kremsmunster	Meridian		— 1.87		+ 4.12	
111		Padua	"		— 0.40		+ 0.20	
112		Vienna	"		— 1.84		+ 1.42	
113	12	Brussels	"		— 1.13		———	
114		"	"		+ 2.32		— 2.98	
115		Markree	"		+ 5.36		+ 2.80	
116		Pulkova	"		+ 0.85		+ 0.63	
117		"	"		+ 0.25		+ 0.50	
118		"	Equatorial	*c*	+ 1.46	10	+ 2.27	10
119	13	Bonn	Meridian		+ 2.11		— 0.66	
120		Brussels	"		— 0.83		———	
121		"	"		+ 5.25		+ 0.38	
122		Cambridge, E.	Equatorial	*a*	— 0.03		+ 3.54	
123		"	Meridian		— 0.51		+ 2.26	
124		Konigsberg	Heliometer	*e*	— 1.40	4	— 0.35	4
125		"	"	*a*	+ 0.77	4	+ 1.46	4
126		Kremsmunster	Meridian		+ 3.27		+ 1.55	
127		Wrottesley	Equatorial		— 0.64	1	+ 4.56	1
128	14	Greenwich	Meridian		— 0.40		— 0.86	
129		Oxford	"		———		+ 1.09	
130		Kremsmunster	"		+ 2.79		— 1.19	
131		Markree	"		+ 3.30		+ 1.46	
132		Vienna	"		— 1.05		+ 1.83	
133	15	Berlin	Equatorial	*b*	— 0.46	7	+ 1.46	7
134		Cambridge, E.	Meridian		— 1.74		+ 3.02	
135		Gottingen	"		+ 3.15		———	
136		Konigsberg	Heliometer	*a*	+ 0.73	6	+ 2.45	6
137		"	"	*e*	+ 0.51	6	+ 2.01	6
138		Kremsmunster	Meridian		— 0.60		— 4.12	
139		Oxford	"		— 1.30		———	
140		Wrottesley	"		— 1.50		———	
141	16	Cambridge, E.	"		+ 0.11		+ 0.62	
142		Greenwich	"		+ 0.63		+ 0.36	
143		Hartwell	"		+ 2.68		———	
144		Kremsmunster	"		+ 1.99		— 5.55	
145		Markree	"		— 0.79		+ 1.51	
146		Naples	Equatorial	*a*	+ 1.86	12	— 2.26	12
147		Oxford	Meridian		+ 0.92		— 0.13	
148	17	Altona	"		+ 0.86		— 1.96	
149		Cambridge, E.	Equatorial	*a*	+ 2.16		+ 1.39	
150		"	Meridian		+ 0.69		+ 1.33	
151		Geneva	"		— 0.52		— 0.41	
152		Hamburg	"		— 0.82		— 2.06	
153		Markree	"		— 0.68		+ 6.34	
154		Naples	Equatorial	*a*	— 1.79	12	— 3.24	12
155		Wrottesley	"		+ 2.00	3	— 3.31	3
156	18	Berlin	"	*b*	+ 1.86	10	+ 1.06	10

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	$\Delta\alpha$	Measures.	$\Delta\delta$	Measures.
					″		″	
157	1846. Oct. 18	Berlin	Equatorial	*b*	— 3.37	10	+ 0.28	10
158		Bonn	"		— 1.43		+ 1.15	
159		Greenwich	"		+ 0.61		+ 1.12	
160		Kremsmunster	"		+ 1.80		— 3.36	
161		Markree	"		+ 0.61		+ 1.12	
162		Naples	Equatorial	*a*	+ 2.22	12	+ 2.50	12
163		South Villa	"	*b*	+ 0.20		+ 2.40	
164	19	Cambridge, E.	Meridian		+ 0.30		+ 1.49	
165		Greenwich	"		+ 0.10		— 0.05	
166		Markree	"		+ 1.36		— 3.01	
167		Naples	Equatorial		+ 1.81	12	+ 0.56	12
168		Padua	Meridian		— 2.80		+ 1.01	
169	20	Brussels	"		— 1.76		———	
170		"	"		— 1.46		— 3.75	
171		Cambridge, E.	"		+ 0.87		+ 2.49	
172		Dorpat	"		+ 2.64		+ 3.16	
173		Durham	Equatorial	*a*	———		+ 2.62	14
174		Gottingen	Meridian		+ 2.08		———	
175		Greenwich	"		— 2.69		— 6.63	
176		Hartwell	"		— 0.53		———	
177		Oxford	"		— 3.21		———	
178		South Villa	Equatorial	*b*	— 2.58		+ 2.27	
179		Naples	"	*a*	+ 1.24	12	+ 1.58	12
180	21	Altona	Meridian		+ 0.26		+ 2.39	
181		Dorpat	"		+ 4.19		+ 0.02	
182		Gottingen	"		— 1.54		+ 4.48	
183		Greenwich	"		— 3.68		+ 1.76	
184		Hamburg	"		— 2.64		— 1.32	
185		Senftenberg	"		+ 2.84		———	
186		Camb., Mass.	Equatorial	*a*	+ 1.57	2	———	
187	22	Gottingen	Meridian		+ 3.86		———	
188		Greenwich	"		— 2.38		+ 0.74	
189	23	Brussels	"		— 5.43		+ 6.62	
190		Buda	"		— 1.71		+ 0.11	
191		Cambridge, E.	"		— 0.90		+ 7.38	
192		Greenwich	"		— 1.95		+ 0.46	
193		Hartwell	"		— 6.05		———	
194		Oxford	"		+ 1.01		+ 1.65	
195		Washington	Equatorial	*a*	+ 0.47		— 0.99	
196	24	Bonn	Meridian		+ 2.22		+ 1.12	
197		Camb., Mass.	Equatorial	*a*	— 1.37		— 1.47	
198		Markree	Meridian		— 3.77		+ 3.97	
199		Washington	Equatorial	*a*	— 2.99	6	+ 1.38	1
200		"	Meridian		+ 3.17		———	
201		"	"		———		+ 1.66	
202		"	"		— 1.95		+ 2.01	
203	25	Dorpat	"		+ 4 26		+ 1.30	
204		Gottingen	"		+ 1.62		———	
205		Hartwell	"		+ 2.63		———	
206		Vienna	"		+ 1.20		———	
207		Washington	Equatorial	*a*	+ 0.88	12	+ 1.23	4
208		"	Meridian		+ 2.64		———	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					″		″	
209	1846. Oct. 25	Washington	Meridian		———		+ 1.44	
210		"	"		+ 3.29		+ 4.54	
211	26	Dorpat	"		— 0.67		— 1.07	
212		Durham	Equatorial	*a*	———		— 1.79	2
213		Liverpool	Meridian		— 0.97		———	
214		Makerstoun	Equatorial	*a*	+ 2.33	13	— 0.69	10
215		Markree	Meridian		+ 2.97		+ 1.20	
216		Petersburg	"		— 2.19		+ 2.83	
217		Pulkova	"		— 1.30		———	
218		"	"		— 0.55		+ 0.82	
219		Washington	Equatorial	*a*	+ 1.66	9	— 0.38	3
220		"	"	*b*	— 0.74	9	— 0.23	3
221		"	"	*c*	— 0.33	4	———	
222		"	Meridian		— 1.30		———	
223	27	Altona	"		+ 0.07		+ 0.15	
224		Berlin	Equatorial	*c*	— 1.18	10	+ 1.54	10
225		Brussels	Meridian		— 4.86		+ 5.76	
226		Buda	"		— 0.92		+ 1.40	
227		Durham	Equatorial	*a*	— 3.06	7	+ 5.30	2
228		Hamburg	Meridian		— 0.23		— 2.25	
229	28	Kremsmunster	"		— 0 72		— 0.79	
230		Washington	Equatorial	*a*	— 3.20	12	— 0.82	10
231		"	"	*b*	+ 4.49	9	— 0.29	9
232		"	"	*c*	+ 1.84	9	— 1.66	10
233		"	Meridian	*a*	+ 2.26	7	———	
234		"	"		———		+ 3.26	
235		Wrottesley	Equatorial		———		+ 6.12	11
236	29	Buda	Meridian		— 0.59		+ 1.30	
237		Camb., Mass.	Equatorial	*a*	+ 1.80		+ 3.12	
238		Durham	"	*a*	— 2.12	11	+ 0.57	2
239		Makerstoun	"	*a*	+ 0.69	10	+ 1.40	10
240		Vienna	Meridian		+ 3.23		+ 3.55	
241		Washington	Equatorial	*a*	— 4.62	9	+ 1.30	10
242		"	"	*b*	— 1.60	9	+ 0.99	10
243		"	"	*c*	— 1.72	9	+ 1.07	10
244		"	Meridian		+ 1.07		———	
245		"	"		———		+ 1.73	
246		"	"	*a*	+ 1.03		+ 1.43	
247	30	Cambridge, E.	Equatorial	*a*	— 0.59		+ 0.16	
248		"	Meridian		— 0.94		+ 3.48	
249		Durham	Equatorial	*a*	+ 0.21		+ 2.46	
250		Kasan	"	*c*	+ 3.22		———	
251		Kremsmunster	Meridian		+ 0.47		— 3.20	
252		South Villa	Equatorial	*b*	— 3.90		+ 2.45	
253		Makerstoun	"	*a*	— 0.43	13	+ 0.95	10
254		Venice	Meridian		+ 0.04		———	
255	31	Geneva	"		— 1.77		+ 0.51	
256		"	Equatorial	*a*	+ 2.92	8	+ 1.88	8
257	Nov. 1	Berlin	"	*c*	— 0.05		+ 1.99	
258		Cambridge, E.	Meridian		— 1.45		+ 0.55	
259		Geneva	"		— 2.18		— 0.91	
260		Hartwell	"		+ 3.57		———	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					″		″	
261	1846. Nov. 1	Konigsberg	Heliometer	*a*	+ 0.23		+ 2.02	
262		"	"	*e*	— 0.48		— 0.65	
263		Kremsmunster	Meridian		+ 2.07		— 1.15	
264		Venice	"	*c*	+ 0.45		———	
265		Venice	"		— 0.79		———	
266		Vienna	"		+ 0.74		+ 0.99	
267	2	Altona	"		+ 1.07		+ 0.78	
268		Berlin	Equatorial	*c*	+ 1.09		+ 0.78	
269		Bonn	Meridian		+ 0.53		+ 1.28	
270		Buda	"		+ 0.97		+ 0.42	
271		Cambridge, E.	Equatorial	*a*	+ 6.81		— 0.56	
272		Geneva	Meridian		— 2.20		+ 0.74	
273		Gottingen	"		— 2.67		———	
274		Hamburg	"		— 3.83		— 0.92	
275		Konigsberg	Equatorial	*a*	+ 0.78		+ 2.00	
276		"	"	*e*	— 2.96		+ 0.96	
277		Kremsmunster	Meridian		— 1.47		— 1.95	
278		Markree	"		— 1.47		+ 3.48	
279	3	Altona	"		— 0.55		+ 1.87	
280		Berlin	Equatorial	*c*	— 0.54		+ 1.62	
281		Bonn	Meridian		— 0.18		+ 3.76	
282		Brussels	"		+ 1.20		+ 1.31	
283		Buda	"		— 1.31		— 1.23	
284		Cambridge, E.	Equatorial	*a*	+ 3.12		+ 3.78	
285		" Mass.	"	*a*	+ 6.44		— 0.51	
286		Gottingen	Meridian		+ 1.45		+ 1.97	
287		"	"		+ 1.85		———	
288		Greenwich	"		— 0.59		— 1.02	
289		Hamburg	"		— 1.15		+ 0.03	
290		Hartwell	"		+ 3.59		———	
291		Konigsberg	Heliometer	*c*	+ 1 06		+ 1.85	
292		"	"	*b*	+ 0.74		+ 0.19	
293		Makerstoun	Equatorial	*a*	+ 1.63	11	+ 1.96	6
294		Washington	"	*a*	+ 0.61		— 1.25	
295		"	"	*b*	— 0.50		———	
296		"	"	*c*	+ 2.58		———	
297	4	Bonn	Meridian		+ 0.29		+ 5.17	
298		Brussells	"		+ 0.79		———	
299		"	"		+ 0.62		— 1.62	
300		Buda	"		— 3.45		+ 0.54	
301		Cambridge, E.	"		+ 2.33		+ 2.32	
302		Greenwich	"		— 1.36		+ 0.87	
303		Hartwell	"		+ 2.11		———	
304		Markree	"		+ 0.40		+ 1.64	
305		Padua	"		+ 5.65		———	
306		Petersburg	"		— 0.59		+ 2.70	
307		Pulkova	"		+ 1.06		+ 0.77	
308		"	"		— 2.54		+ 0.94	
309		"	Equatorial	*c*	+ 0.02		+ 1.09	
310	5	Bonn	Meridian		— 0.44		+ 3.52	
311		Brussells	"		+ 2 90		+ 0.01	
312		"	"		+ 4.43		+ 3.12	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					″		″	
313	1846. Nov. 5	Buda	Meridian		— 3.32		+ 0.60	
314		Camb., Mass.	Equatorial	*a*	— 0.01	6	— 2.76	6
315		Dorpat	Meridian		— 1.12		+ 3.29	
316		Petersburg	"		— 1.74		+ 2.09	
317		Pulkova	"		+ 0.35		+ 0.33	
318		Pulkova	"		———		— 0.78	
319		"	Equatorial	*c*	+ 0.02		+ 1.32	
320		Venice	Meridian		+ 1.96		———	
321		Vienna	"		———		— 0.89	
322	6	Berlin	Equatorial	*c*	+ 0.87	15	+ 1.11	15
323		Bonn	Meridian		— 1.24		+ 3.52	
324		Buda	"		+ 1.27		+ 1.41	
325		Camb., Mass.	Equatorial	*a*	+ 3.08	9	— 2.49	9
326		Padua	Meridian		+ 4.42		+ 0.87	
327		Venice	"		+ 0.07		———	
328	7	Buda	"		— 0.84		+ 1.00	
329		Durham	Equatorial	*a*	+ 2.05	13	+ 4.40	8
330		Venice	Meridian		+ 1.15		———	
331		"	"	*c*	+ 1.66		———	
332	8	Buda	"		+ 2.58		+ 0.89	
333		Christiania	"		— 1.50		+ 6.21	
334		Geneva	"		— 1.36		+ 0.87	
335		"	Equatorial		— 4.76	4	+ 2.76	1
336		Petersburg	Meridian		+ 2.07		+ 1.14	
337		Pulkova	"		———		+ 0.09	
338	9	Buda	"		— 3.93		— 0.73	
339		Christiania	"		+ 6.14		+ 0.70	
340		Durham	Equatorial	*a*	———		+ 2.16	
341		Georget'n, D.C.	Meridian		+ 5.48		———	
342		Makerstoun	Equatorial	*a*	+ 1.42	10	— 0.59	2
343		Markree	Meridian		+ 0.05		+ 2.24	
344		Washington	Equatorial	*a*	+ 1.62	9	+ 0.07	6
345		"	"	*b*	— 1.58	9	+ 0.18	3
346		"	"	*c*	— 0.22	9	+ 2.55	6
347	10	Berlin	"	*c*	— 1.67	10	— 0.35	10
348		Bonn	Meridian		+ 0.27		+ 4.65	
349		Brussells	"		— 0.78		+ 1.44	
350		"	"		+ 0.12		— 1.66	
351		Buda	"		— 1.82		— 0.31	
352		Durham	Equatorial	*a*	———	22	+ 4.58	3
353		Hamburg	Meridian		— 2.16		— 0.90	
354		Liverpool	"		+ 0.13		———	
355		Makerstoun	Equatorial	*a*	+ 0.59	17	— 0.16	10
356		Markree	Meridian		+ 2.43		+ 4.68	
357		Washington	Equatorial		— 1.41		———	
358		"	"	*a*	— 2.38		+ 1.27	
359	11	Bonn	"		— 1.61		+ 4.80	
360		Brussels	"		— 4.68		— 0.72	
361		"	"		— 1.10		— 2.52	
362		Buda	"		— 2.19		— 0.53	
363		Cambridge, E.	"		— 0.52		+ 1.60	
364		Geneva	Meridian		— 3.28		— 0.84	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					″		″	
365	1846. Nov. 11	Greenwich	Meridian		— 0.65		+ 0.22	
366		Kremsmunster	Equatorial		+ 1.66		+ 0.41	
367		Markree	Meridian		+ 3.24		+ 0.62	
368		Naples	Equatorial	*a*	— 0.25	12	— 0.51	12
369		Oxford	Meridian		+ 0.95		— 0.44	
370		Padua	"		+ 2.27		— 0.23	
371		Vienna	"		+ 2.56		+ 1.09	
372	12	Bonn	"		+ 1.10		+ 5.07	
373		Brussels	"		+ 4.44		+ 5.48	
374		Dorpat	"		+ 0.23		+ 2.52	
375		Konigsberg	Heliometer	*c*	+ 1.04	4	+ 0.85	4
376		"	"	*b*	— 0.26	4	+ 1.04	4
377		Padua	Meridian		— 0.75		— 1.67	
378		Petersburg	"		— 4.94		+ 1.34	
379	13	Bonn	"		— 2.89		+ 4.94	
380		Brussels	"		+ 4.66		———	
381		Buda	"		+ 1.47		+ 0.72	
382		Kremsmunster	"		+ 3.08		+ 0.06	
383		Venice	"		+ 4.65		———	
384		Vienna	"		+ 1.36		+ 0.13	
385	14	Buda	"		+ 2.38		+ 2.49	
386		Venice	"		+ 0.44		———	
387		"	"		+ 0.94		———	
388		Vienna	"	*c*	+ 2.97		— 2.16	
389		Padua	"		— 2.38		— 0.49	
390	15	Altona	"		+ 0.19		— 0.21	
391		Hamburgh	"		— 2.91		+ 1.69	
392		Naples	"		— 0.56		+ 1.94	
393	16	Altona	"		+ 1.36		— 0.09	
394		Berlin	Equatorial	*b*	+ 0.96	10	+ 2.13	10
395		"	"	*c*	+ 0.79	10	— 2.51	10
396		Bonn	Meridian		— 0.18		+ 3.83	
397		Buda	"		— 1.29		+ 0.33	
398		Cambridge	"		+ 1.28		+ 0.89	
399		"	Equatorial	*a*	+ 3.23		+ 2.65	
400		Christiania	Meridian		+ 2.13		— 2.60	
401		Hamburgh	"		+ 0.86		+ 0.61	
402		Kremsmunster	"		+ 2.80		— 3.70	
403		Naples	Equatorial	*a*	— 0.46	12	+ 2.22	12
404		Padua	Meridian		— 0.49		+ 0.83	
405		Pulkova	"		+ 1.24		— 2.48	
406		Venice	"		— 2.73		———	
407		"	"		+ 0.69		———	
408		Washington	Equatorial	*a*	— 4.01		+ 0.75	
409	17	Altona	Meridian		+ 0.73		— 0.22	
410		Berlin	Equatorial	*b*	— 3.52	14	— 0.53	20
411		Bonn	Meridian		+ 0.12		+ 2.44	
412		Buda	"		— 1.04		— 0.42	
413		Gottingen	"		+ 1.73		———	
414		Hamburgh	"		— 1.87		— 0.92	
415		Liverpool	"		+ 0.11		———	
416		Markree	"		+ 4.61		+ 2.24	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					″		″	
417	1846. Nov. 17	Kremsmunster	Meridian		+ 3.33		— 6.22	
418	18	Berlin	Equatorial	*b*	+ 1.58	12	+ 0.30	12
419		Buda	Meridian		+ 0.63		+ 0.30	
420		Cambridge, E.	"		+ 0.91		+ 1.05	
421		" "	Equatorial	*a*	+ 4.51	3	+ 0.06	3
422		" Mass.	"	*a*	— 5.61	6	— 4.60	6
423		Greenwich	Meridian		— 0.89		+ 0.77	
424		Konigsberg	Heliometer	*c*	+ 1.21	4	+ 1.37	4
425		"	"	*b*	— 0.06	4	+ 0.01	4
426		Kremsmunster	Meridian		+ 4.96		— 1.11	
427		Venice	"		+ 0.11		———	
428		Vienna	"		+ 0.74		———	
429	19	Bonn	"		— 0.14		+ 1.04	
430		Buda	"		— 2.95		— 1.64	
431		Cambridge, E.	"		+ 6.60		+ 2.57	
432		"	Equatorial	*a*	+ 3.52	6	+ 0.47	6
433		Durham	"	*a*	———	6	+ 2.66	6
434		Geneva	Meridian		— 1.68		— 0.53	
435		Greenwich	"		— 3.31		— 0.66	
436		Konigsberg	Equatorial	*k*	— 0.04	4	— 0.16	4
437		"	"	*a*	+ 0.25	8	+ 2.88	8
438		Kremsmunster	Meridian		+ 4.65		— 4.23	
439		Makerstoun	Equatorial	*a*	— 0.20	18	+ 1.56	7
440		Vienna	Meridian		— 0.80		+ 0.10	
441	20	Berlin	Equatorial	*b*	— 1.47	15	— 0.36	15
442		Cambridge, E.	Meridian		———		+ 2.57	
443		Kasan	Equatorial	*c*	+ 0.51	4	+ 0.30	4
444		Kremsmunster	Meridian		+ 0.44		— 6.36	
445	21	Cambridge, E.	"		+ 1.69		+ 3.75	
446		" Mass.	Equatorial	*a*	+ 6.00		— 1.70	
447		Christiania	Meridian		+ 3.02		— 3.37	
448		Durham	Equatorial	*a*	———		+ 0.36	2
449		Greenwich	Meridian		— 1.49		+ 0.87	
450		Hamburg	"		+ 2.85		+ 2.18	
451		Washington	"	*a*	— 0.18		+ 3.02	
452		"	"		———		+ 2.78	
453	22	Cambridge, E.	"		— 3.04		+ 3.40	
454	23	Hamburg	"		— 3.12		— 0.14	
455		Venice	"		— 2.96		———	
456		Washington	"		— 0.81		———	
457		"	"		———		+ 2.98	
458		"	"	*a*	— 0.26		+ 4.14	
459	24	Cambridge, E.	"		+ 0.24		+ 3.10	
460		" Mass.	Equatorial	*a*	— 0.23	7	— 2.03	
461		Durham	"	*a*	— 2.94	16	+ 3.23	1
462		Makerstoun	"	*a*	— 0.56	16	— 0.06	6
463		Markree	Meridian		+ 2.01		+ 2.94	
464	25	Geneva	"		— 3.03		+ 4.85	
465		Padua	"		+ 0.65		— 0.93	6
466		Venice	"		+ 4.25		———	
467		"	"	*c*	+ 1.60		———	
468	26	Cambridge, E.	Equatorial	*a*	+ 0.68	4	+ 1.02	4

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					"		"	
469	1846. Nov. 26	Cambridge, E.	Meridian		— 2.58		+ 4.20	
470		Greenwich	"		———		— 4.43	
471	27	Durham	Equatorial	*a*	+ 2.94	4	— 0.70	4
472	28	Cambridge, E.	Meridian		— 2.23		+ 2.32	
473		Liverpool	"		+ 0.40		———	
474		Markree,	"		+ 4.36		+ 3.27	
475		Oxford	"		———		+ 2.40	
476		Washington, E.	Equatorial	*a*	+ 1.48	24	— 0.08	17
477	29	Buda	Meridian		— 1.29		— 1.01	
478		Christiania	"		— 1.24		— 0.88	
479		Hamburgh	"		— 1.90		+ 2.69	
480		Kremsmunster	"		+ 5.31		— 1.30	
481		Liverpool	"		— 2.70		———	
482		Washington	Equatorial	*a*	— 0.82	12	— 0.27	5
483		"	"	*b*	———		+ 0.96	
484	30	Cambridge, E.	Meridian		— 0.56		+ 2.24	
485		Christiania	"		— 2.88		+ 2.17	
486		Durham	Equatorial	*a*	— 0.84	20	— 1.48	7
487		Gottingen	Meridian		+ 4.90		+ 0.96	
488		Liverpool	"		+ 1.25		———	
489		Washington	"	*a*	+ 1.89		+ 2.64	
490	Dec. 1	Altona	"		+ 1.82		— 0.57	
491		Berlin	Equatorial	*b*	— 0.54	15	+ 0.21	15
492		Bonn	Meridian		— 0.95		— 0.50	
493		Cambridge, E.	"		+ 1.21		+ 2.44	
494		Durham	Equatorial	*a*	+ 1 26	20	+ 4.90	5
495		Gottingen	Meridian		+ 6.12		———	
496		Hamburgh	"		— 5.18		+ 0.13	
497		Makerstoun	Equatorial	*a*	+ 4.50	15	+ 1.40	5
498	2	Altona	Meridian		— 1.19		+ 1.46	
499		Christiania	"		— 4.40		+ 1.31	
500		Durham	Equatorial	*a*	— 0.24	20	+ 2.91	4
501		Hamburgh	Meridian		— 1.39		+ 0.46	
502		Konigsberg	Heliometer	*c*	+ 1.44	4	+ 1.37	4
503		"	"	*b*	+ 0.72		+ 0.21	5
504		Makerstoun	Equatorial	*a*	— 1.62	16	+ 0.56	
505		Washington	Meridian	*a*	+ 3.29		+ 1.81	
506	3	Altona	"		— .29		+ 2.13	6
507		Camb., Mass.	Equatorial	*a*	+ 3.92	6	+ 1.57	4
508		Christiania	Meridian		— 0.54	4	— 0.74	
509		"	"	*a*	— 1.49		———	
510		Kasan	Equatorial	*c*	+ 0.31		+ 3.67	
511		Hamburg	Meridian		— 3.59		— 1.47	
512		Liverpool	"		— 0.14		———	
513		Markree	"		+ 1.32		+ 2.23	6
514		Washington	Equatorial	*a*	+ 0.41	12	+ 1.22	3
515		"	"	*b*	— 1.34	6	+ 2.16	
516		"	Meridian		— 1.07		———	
517		"	"		———		+ 1.86	
518	4	Altona	"		— 1.08		+ 0.37	
519		Bonn	"		— 0.02		+ 1.81	
520		Cambridge	"		— 5.57		+ 1.21	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	△ α	Measures.	△ δ	Measures.
					″		″	
521	1846. Dec. 4	Christiania	Meridian		— 1.12		— 1.40	
522		"	"	a	— 0.73		———	
523		Durham	Equatorial	a	+ 0.94		+ 2.12	
524		Greenwich	Meridian		+ 0.99		+ 2.63	
525		Hamburg	Equatorial		— 2.68		— 0.93	
526		Konigsberg	Heliometer	b	— 0.20	4	+ 0.34	4
527		"	"	c	+ 0.92	4	+ 1.00	4
528		Makerstoun	Equatorial	a	— 0.35	16	+ 1.24	5
529		Markree	Meridian		— 0.09		+ 4.12	
530		Washington	"	a	— 2.12		———	
531	5	Durham	Equatorial	a	+ 3.84	6	———	
532		Petersburg	Meridian		— 3.01		— 1.60	
533		Pulkova	Equatorial	b	+ 0.44		———	
534	6	Geneva	Meridian		+ 1.03		— 2.05	
535		Liverpool	"		— 1.31		———	
536	7	Altona	"		+ 1.43		+ 1.47	
537		Bonn	"		+ 3.77		+ 2.46	
538		Hamburg	"		— 2.37		— 0.83	
539		Pulkova	"		+ 1.67		— 1.98	
540		"	Equatorial	b	+ 2.50		+ 0.18	
541	8	Kasan	"	b	— 1.04	8	— 3.49	4
542	9	Camb., Mass.	"	a	+ 1.18	9	— 0.13	2
543		Washington	"	a	+ 3.58	3	— 0.04	2
544		"	"	b	+ 0.04	6	— 0.69	6
545	11	Cambridge, E.	Equatorial	a	+ 4.85	6	+ 0.78	2
546		Christiania	Meridian		— 1.18		+ 2.74	
547		"	"	a	— 1.14		———	
548		Hamburg	"		— 2.58		+ 1.99	
549		Liverpool	"		— 2.39		———	
550	12	Cambridge, E.	Equatorial		+ 3.30	6	+ 2.62	6
551		Christiania	Meridian		— 1.03		+ 1.75	
552		"	"	a	— 0.50		———	
553		Washington	Equatorial	a	+ 6.03	23	+ 1.65	7
554		"	"	b	— 0.14	24	———	
555		"	"	c	+ 3.00	6	———	
556	13	Cambridge, E.	Meridian		+ 3.90		+ 4.21	
557		Christiania	"		— 3.75		+ 3.00	
558		"	"	a	— 1.54		———	
559		Liverpool	"		— 2.37		———	
560		Washington	Equatorial	a	+ 0.70	25	+ 1.43	9
561		"	"	b	— 1.23	9	+ 1.82	9
562		"	"	c	— 3.77	5	———	
563	14	Cambridge, E.	"	a	+ 2.64		+ 1.77	
564		Camb., Mass.	"	a	+ 6.76		— 5.66	
565		Liverpool	"		+ 1.85		———	
566		Markree	"		+ 3.45		+ 1.42	
567	15	Cambridge, E.	"	a	+ 2.94		+ 1.94	
568		Konigsberg	Heliometer	k	+ 0.42		— 0 07	
569		Liverpool	Meridian		— 0.04		———	
570		Markree	"		+ 3.34		+ 2.50	
571		Washington	Equatorial	a	+ 4.93	5	+ 0.92	5
572		"	"	b	+ 1.09	4	+ 3.31	3

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					″		″	
573	1846. Dec. 15	Washington	Equatorial	*c*	+ 1.61	3	———	
574	16	Konigsberg	Heliometer	*k*	— 0.12	6	+ 0.18	
575		Dorpat	Meridian		+ 0.60		+ 1.90	
576		Liverpool	"		— 0.79		———	
577	17	"	"		+ 0.67		———	
578		Markree	"		+ 3.34		+ 0.43	
579	18	Cambridge, E.	Equatorial	*a*	+ 2.48	4	+ 2.36	4
580	19	Christiania	Meridian		———		— 1.68	
581		Washington	Equatorial	*a*	+ 0.19	14	+ 1.38	5
582		"	"	*b*	— 0.75	17	+ 0.67	3
583		"	"	*c*	— 4.53	3	———	
584	20	Kasan	"	*b*	— 4.32		— 0.88	
585		Washington	"	*a*	+ 0.93	24	+ 2.23	7
586		"	"	*b*	— 0.70	23	+ 1.98	
587		"	"	*c*	+ 1.60	3	———	
588	21	Camb., Mass.	"	*a*	+ 0.98	3	+ 2.89	3
589		Geneva	"	*a*	———	6	+ 2.65	6
590		Vienna	"	*a*	———		+ 0.79	
591		Pulkova	Meridian		———		— 0.14	
592		"	Equatorial	*b*	+ 1.76		+ 2.18	
593	22	Kasan	"	*b*	— 0.54	6	— 3.41	4
594		Greenwich	"	*a*	— 9.96	5	+ 1.64	5
595	23	Washington	"	*a*	+ 4.91	24	+ 2.24	6
596		"	"	*b*	+ 0.48	24	———	
597		"	"	*d*	+ 1.88	5	+ 2.79	2
598	24	Hamburg	"		+ 1.00	14	+ 1.35	14
599	26	Washington	"	*a*	+ 3.03	36	+ 1.42	8
600		"	"	*b*	+ 0.83	36	+ 1.86	8
601		"	"	*d*	— 3.20	3	— 3.24	1
602	27	Hamburg	"		— 0.51	8	+ 2.73	8
603	28	"	"		+ 0.15	8	+ 3.82	8
604		Konigsberg	Heliometer	*e*	+ 2.06	8	+ 0.45	8
605	29	Kasan	Equatorial	*d*	+ 4.77	6	+ 2.38	6
606	30	Konigsberg	Heliometer	*e*	+ 0.95	6	+ 0.05	6
607		Washington	Equatorial	*a*	— 1.64	6	+ 0.90	6
608	1847. Jan. 3	Breslaw	"		———		+ 4.72	
609	4	"	"		— 2.39		+ 7.71	
610	5	Camb., Mass.	"	*a*	— 3.35	4	+ 3.79	4
611		Hamburg	"		— 0.28	4	— 3.77	4
612		Washington	"	*a*	— 3.19	16	+ 0.47	6
613		"	"	*b*	— 0.96	16	+ 1.42	6
614		"	"	*d*	+ 1.37	8	+ 1.58	2
615	6	Kasan	"	*d*	+ 0.66	10	+ 8.48	8
616	8	Hamburg	"		+ 6.62	3	— 6.74	3
617		Pulkova	"	*d*	— 1.50		+ 1.01	
618		Washington	"	*a*	— 3.82	6	+ 0.98	3
619		"	"	*b*	+ 1.98	6	+ 1.27	3
620		"	"	*d*	— 2.13	6	+ 1.38	3
621	9	Kasan	"	*d*	— 1.24	8	+ 8.74	8
622	10	Breslaw	"		+ 3.64		+ 2.10	
623	11	Cambridge, E.	"		+ 2.04	6	— 0.47	6
624		Breslaw	"	*a*	— 5.13		+ 5.15	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					"		"	
625	1847. Jan. 11	Breslaw	Equatorial		+ 5.22		+ 3.15	
626		Hamburg	"	*d*	+ 2.29	7	+ 0.72	7
627		Kasan	"	*d*	+ 2.01	8	+ 6.10	8
628	12	Breslaw	"		— 1.39		+ 5.82	
629		Cambridge, E.	"	*a*	+ 7.86	6	+ 1.45	6
630		Hamburg	"		— 3.85	5	— 1.43	5
631		Washington	"	*a*	— 2.32	6	+ 1 55	1
632		"	"	*d*	+ 0.45	17	+ 3.70	7
633	13	Hamburg	"		+ 1.53	6	+ 3.87	6
634		Breslaw	"		— 0.97		+ 7.41	
635		Kasan	"	*k*	+ 5.65		———	
636	14	Cambridge, E.	"	*a*	+ 2.99	6	— 0.82	6
637	15	"	"	*a*	+ 9.23	6	+ 4.03	6
638	16	Breslaw	"		— 6.26		— 7.45	
639	18	"	"		+ 0.29		+ 2.42	
640	19	Camb., Mass.	"	*a*	+ 6.61	3	+ 6.07	3
641	22	Washington	"	*d*	+ 1.72	15	— 0.27	5
642	25	Camb., Mass.	"	*a*	+ 10.69	3	+ 3.72	3
643	27	Washington	"	*d*	+ 7.14	4	+ 1.16	2
644	Mar. 24	"	"	*f*	+ 3.07	15	+ 0.49	5
645	April 2	"	"	*f*	+ 3.04	9	— 1.15	3
646	4	"	"	*f*	+ 1.86	18	+ 1.01	4
647	6	"	"	*f*	— 1.23	24	— 0.26	8
648	7	"	"	*f*	+ 1.03	30	+ 0.19	10
649	9	"	"	*f*	— 4.57	24	+ 0.91	8
650	11	"	"	*f*	+ 0.39	9	+ 0.15	3
651	30	"	"	*g*	+ 0.72	18	— 1.52	6
652	May 6	Cambridge, E.	"		— 4.55		+ 0.77	
653	7	Washington	"	*g*	— 1.29	18	— 1.96	6
654	11	Cambridge, E.	"		— 0.28		+ 0.08	
655	14	Camb., Mass.	"	*g*	— 0.00	4	+ 4.13	4
656	16	Washington	"	*g*	— 0.32	18	— 2.75	5
657	19	Camb., Mass.	"	*g*	+ 7.25	1	+ 2.56	1
658	20	"	"	*g*	+ 0.28	6	+ 0.00	6
659	26	Cambridge, E.	"		+ 2.44		+ 0.19	
660	28	Camb., Mass.	"	*g*	— 0.04	5	— 2.29	5
661	June 1	Cambridge, E.	"		+ 2.09		+ 0.44	
662	6	Washington	"	*g*	+ 3.66	9	— 3.10	5
663	14	Hamburg	"		— 10.93		+ 9.78	5
664	17	"	"		+ 7.19	1	+ 9.53	1
665	18	"	"		— 1.69	3	— 0.68	3
666	19	Cambridge, E.	"		+ 0.26		+ 0.36	
667	20	Hamburg	"		— 6.39	3	+ 5.17	3
668	23	"	"		— 5.39	9	+ 0.27	9
669	24	"	"		— 4.72	13	+ 1.38	13
670	28	"	"		— 4.60	8	+ 1.24	8
671	July 3	"	"		— 4.34	11	+ 1.92	5
652	5	"	"		— 0 82	7	+ 2.57	7
673	13	Cambridge, E.	"		— 1.72		— 0.64	
674	14	Makerstoun	"		+ 0 83	2	+ 0.06	2
675	21	Greenwich	Meridian		— 0.26		+ 2.10	
676	22	Cambridge, E.	"		— 0.80		+ 3.93	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					″		″	
677	1847. July 22	Durham	Meridian		— 2.26		— 2.70	
678	23	Greenwich	"		— 3.68		+ 0.84	
679	26	Cambridge, E.	"		— 0.02		+ 2.44	
680	27	"	"		— 1.56		———	
681		Greenwich	"		— 3.57		+ 3.83	
682	28	Philadelphia	"		+ 0.20		———	
683		"	Equatorial	*f*	— 1.55	12	— 2.10	4
684	29	Cambridge, E.	Meridian		— 0.56		— 0.14	
685	30	"	"		+ 0.21		+ 4.95	
686		Greenwich	"		— 2.08		+ 1.38	
687		Hamburgh	"		— 3.91		— 2.89	
688	31	"	"		+ 0.80		— 3.36	
689	Aug. 1	"	"		— 0.36		— 1.81	
690	2	Christiania	"		+ 1.72		— 2.91	
691		Makerstoun	Equatorial	*f*	+ 1.32	6	+ 2.16	6
692		Philadelphia	"	*f*	— 1.94	24	+ 0.80	8
693	3	Altona	Meridian		— 3.01		— 3.46	
694		Cambridge, E.	"		— 1.79		+ 4.22	
695		Greenwich	"		— 0.93		+ 2.11	
696		Hamburg	"		— 1.51		— 4.79	
697		Philadelphia	"		+ 2.76		———	
698	4	Altona	"		———		— 1.10	
699		Christiania	"		— 0.54		— 0.26	
700	5	"	"		+ 1.54		— 0.10	
701	6	"	"		— 2.64		+ 2.64	
702		Hamburgh	"		+ 1.04		— 0.47	
703	7	Cambridge, E.	"		+ 0.68		+ 4.05	
704		"	Equatorial	*f*	— 1.50	1	— 1.19	1
705		Makerstoun	"	*f*	— 0.60	8	+ 1.00	8
706	8	Kremsmunster	Meridian		— 1.79		— 4.56	
707	9	Cambridge, E.	"		— 4.34		— 1.86	
708		Durham	Equatorial	*f*	— 1.30	5	+ 1.02	5
709		Greenwich	Meridian		— 1.94		+ 3.35	
710		Hamburgh	"		+ 0.72		— 2.13	
711	10	Cambridge, E.	Meridian		— 1.77		+ 5.16	
712		Christiania	"		— 2.25		———	
713		Greenwich	"		— 3.27		+ 3.29	
714	11	Cambridge, E.	"		+ 1.20		+ 2.90	
715		Hamburgh	"		— 1.86		— 0.79	
716		Kremsmunster	"		— 1.45		+ 3.19	
717	12	Cape G. H.	"		— 1.90		+ 0.58	
718		Gottingen	"		— 0.52		— 0.52	
719		Hamburgh	"		— 1.82		— 3.22	
720		Kremsmunster	"		+ 1.02		+ 0.57	
721	13	Cambridge, E.	"		+ 0.00		+ 7.14	
722		Christiania	"		— 0.66		— 0.66	
723		Durham	"		— 0.18		+ 0.92	
724		"	Equatorial	*f*	— 1.47	7	— 1.69	7
725		Greenwich	Meridian		— 1.66		+ 3.20	
726		Gottingen	"		+ 1.80		+ 1.52	
727		Kremsmunster	"		+ 3.98		+ 2.68	
728		Petersburgh	"		+ 0.01		+ 2.76	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					"		"	
729	1847. Aug. 14	Cambridge, E.	Meridian		— 0.71		———	
730		Durham	Equatorial	*f*	— 1.01	7	+ 2.56	7
731		Gottingen	Meridian		— 2.35		+ 1.33	
732		Hamburgh	"		+ 0.25		— 1.67	
733		Kremsmunster	"		+ 1.22		+ 1.17	
734	15	Bonn	"		— 2.87		— 0.35	
735		Christiania	"		— 0.32		+ 0.75	
736		Kremsmunster	"		— 0.41		+ 1.52	
737	16	Bonn	"		— 1.70		+ 2.21	
738		Cape G. H.	"		+ 0.37		+ 2.05	
739		Hamburgh	"		+ 0.05		— 3.32	
740		Kremsmunster	"		+ 0.30		+ 2.95	
741		Petersburgh	"		— 4.05		+ 4.51	
742	17	Christiania	"		— 3.57		+ 0.73	
743		Gottingen	"		+ 1.49		+ 0.41	
744		Hamburgh	"		— 1.71		— 2.99	
745		Kremsmunster	"		+ 0.06		+ 2.06	
746		Poona	Equatorial	*f*	— 1 44		+ 3.79	
747	18	Camb., Mass.	"	*f*	+ 3.05	4	+ 0.63	4
748		Cape G. H.	Meridian		+ 1.41		+ 2.11	
749		Christiania	"		— 0.68		+ 2.22	
750		Hamburgh	"		+ 0.94		— 2.41	
751		Konigsberg	"		— 3.46		— 0.52	
752		"	Heliometer	*h*	— 1.36		+ 0.33	
753		Kremsmunster	Meridian		— 0.52		+ 2.59	
754		Petersburgh	"		— 3.45		+ 1.53	
755	19	Cape G. H.	"		— 1.14		+ 2.66	
756		Christiania	"		+ 1.66		+ 1.72	
757		Durham	"		+ 0.63		+ 6.15	
758		"	Equatorial	*f*	— 3.10	4	+ 2.92	4
759		Hamburgh	Meridian		— 2.88		+ 0.09	
760		Konigsberg	"		— 1.86		+ 1.97	
761		"	Heliometer	*h*	— 1.10		+ 0.47	
762		Petersburgh	Meridian		+ 4.18		— 1.18	
763	20	Cambridge, E.	"		— 0.46		+ 3.17	
764		Camb., Mass.	Equatorial	*f*	+ 3.05	8	+ 0.56	4
765		Cape G. H.	Meridian		— 0.74		+ 1.86	
766		Greenwich	"		— 1.79		— 0.29	
767		Hamburgh	"		+ 0.34		— 3.92	
768		Kremsmunster	"		+ 3.04		+ 1.24	
769		Petersburgh	"		+ 0.18		+ 0.31	
770	21	Cambridge, E.	"		— 1.93		+ 2.28	
771		"	Equatorial	*f*	+ 2.54	10	+ 0.27	8
772		Cape G. H.	Meridian		— 2.82		+ 1.89	
773		Christiania	"		— 3.04		+ 4.40	
774		Greenwich	"		— 2.52		— 0.81	
775		Hamburgh	"		+ 1.69		+ 1.86	
776		Petersburgh	"		— 5.67		+ 0.08	
777	22	Konigsberg	"		———		— 4.77	
778		"	Heliometer	*h*	— 1.23		— 0.10	
779		Makerstoun	"	*f*	+ 0.40	7	— 0.32	7
780	23	Cambridge, E.	Meridian		— 3.70		+ 2.01	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					″		″	
781	1847. Aug. 23	Cambridge, E.	Equatorial	*f*	— 1.33	6	— 1.17	10
782		Christiania	Meridian		+ 2.05		+ 3.87	
783		Durham	Equatorial	*f*	— 1.86	7	+ 1.34	7
784		Petersburgh	Meridian		— 3.06		———	
785	24	Cambridge, E.	"		— 1.76		+ 1.62	
786		Christiania	"		— 0.64		+ 2.94	
787		Durham	Equatorial	*f*	— 2.23	3	+ 2.18	3
788	25	Cape G. H.	Meridian		+ 1.51		+ 2.41	
789		Christiania	"		+ 1.24		— 0.31	
790	26	Cape G. H.	"		— 4.04		+ 0.69	
791		Christiania	"		— 1.76		— 2.40	
792		Greenwich	"		— 1.22		+ 4.77	
793		Hamburgh	"		— 2.57		— 1.51	
794	27	Cambridge, E.	"		— 1.05		+ 3.45	
795		Cape G. H.	"		— 3.25		+ 1.33	
796	28	Altona	"		+ 0.05		— 3.86	
797		Christiania	"		+ 1.09		+ 0.67	
798		Hamburgh	"		— 1.27		— 1.36	
799		Konigsberg	"		— 0.04		+ 0.54	
800		"	Heliometer	*h*	— 1.00		— 0.21	
801	29	Christiania	Meridian		+ 0.23		+ 1.77	
802		Kremsmunster	"		+ 3.38		— 1.71	
803	30	Christiania	"		+ 2.79		+ 0.51	
804		Kremsmunster	"		+ 2.21		— 0.61	
805		Petersburgh	"		+ 1.31		— 1.76	
806	31	Altona	"		— 0.84		— 3.26	
807		Cambridge, E.	"		— 1.43		+ 5.44	
808		Cape G. H.	"		— 0.93		———	
809		Christiania	"		———		+ 1.11	
810		Durham	Equatorial	*f*	— 1.26	7	— 2.29	7
811		Hamburgh	Meridian		— 0.14		— 0.90	
812		Petersburgh	"		— 5.81		+ 3.54	
813	Sept. 1	Cambridge, E.	"		— 0.34		+ 3.83	
814		Cape G. H.	"		— 3.15		+ 0.95	
815		Durham	Equatorial	*f*	— 2.65	6	— 0.75	6
816		Greenwich	Meridian		— 2.58		+ 1.02	
817		Petersburgh	"		— 8.88		+ 1.54	
818	2	Cambridge, E.	"		— 1.10		+ 0.32	
819		Cape G. H.	"		— 1.90		———	
820		Durham	"		— 1.87		———	
821		"	Equatorial	*f*	— 2.32	2	+ 2.46	2
822		Greenwich	Meridian		+ 1.45		+ 2.49	
823		Konigsberg	"		— 0.25		+ 1.77	
824	3	Cape G. H.	"		— 2.12		+ 0.90	
825		Durham	"		+ 0.14		— 3.87	
826		"	Equatorial	*f&g*	— 0.36	11	+ 1.29	11
827		Kremsmunster	Meridian		+ 2.77		+ 4.12	
828	4	Bonn	"		— 0.56		+ 2.78	
829		Cambridge, E.	"		— 0.48		+ 1.33	
830		Cape G. H.	"		— 3.18		+ 2.17	
831		Durham	"		— 0.53		— 0.54	
832		"	Equatorial	*f&g*	— 0.80	11	— 3.30	9

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					″		″	
833	1847. Sept. 4	Greenwich	Meridian		— 0.30		+ 3.51	
834		Makerstoun	Equatorial	*f*	+ 0.97	8	— 2.34	3
835		"	"	*h*	+ 0.76	15	+ 1.22	7
836	5	Kasan	"	*h*	— 1.99	12	+ 1.22	5
837	6	Altona	Meridian		+ 1.60		— 1.40	
838		Cape G. H.	"		— 1.38		— 2.67	
839		Kasan	Equatorial	*h*	+ 3.68	16	— 0.03	8
840		Konigsberg	Meridian		— 0.23		+ 3.85	
841		Makerstoun	Equatorial	*h*	+ 0.76	11	+ 0.94	11
842	7	Altona	Meridian		+ 1.17		— 1.14	
843		Cape G. H.	"		— 1.19		+ 0.19	
844		Christiania	"		+ 1.51		+ 0.58	
845		Hamburgh	"		— 3.49		———	
846	8	Cambridge, E.	"		+ 0.50		+ 3.79	
847		Kasan	Equatorial	*h*	+ 4.13	10	— 1.87	8
848		Kremsmunster	Meridian		— 3.93		———	
849		Petersburgh	"		+ 5.41		+ 1.10	
850	9	Cambridge, E.	"		— 0.82		+ 3.15	
851		Kasan	Equatorial	*h*	+ 0.60	10	— 2.39	5
852		Petersburgh	Meridian		+ 1.20		+ 3.59	
853	10	Durham	Equatorial	*g*	— 4.38	5	+ 0.90	5
854		Greenwich	Meridian		— 1.80		+ 1.18	
855		Hamburg	"		— 3.48		———	
856		Konigsberg	"		— 2.74		+ 0.39	
857		Kremsmunster	"		— 1.32		+ 1.01	
858		Petersburgh	"		+ 0.56		+ 4.03	
859	11	Konigsberg	"		— 0.82		— 0.35	
860		Kremsmunster	"		+ 0.57		+ 2.96	
861		Petersburgh	"		— 2.72		+ 0.47	
862	12	Cape G. H.	"		+ 1.88		+ 0.84	
863		Christiania	"		— 1.60		———	
864		Kremsmunster	"		— 1.73		+ 2.67	
865	13	Cape G. H.	"		— 2.71		+ 0.96	
866		Christiania	"		———		— 9.29	
867		Durham	Equatorial	*g*	+ 1.55	7	— 0.79	7
868		Gustau	"					
869		Konigsberg	Meridian		— 0.65		— 0.16	
870		Kremsmunster	"		— 4.79		+ 2.27	
871		Makerstoun	Equatorial	*h*	— 0.18	7	+ 1.47	7
872	14	Cape G. H.	Meridian		— 1.27		———	
873		Durham	Equatorial	*g*	+ 0.40	8	+ 1.01	8
874		Greenwich	Meridian		— 1.37		+ 1.40	
875		Konigsberg	"		— 1.52		+ 1.78	
876		Petersburgh	"		— 2.65		+ 1.25	
877	15	Altona	"		+ 0.04		— 1.31	
878		Cape G. H.	"		— 3.79		+ 2.18	
879		Christiania	"		+ 0.74		+ 1.84	
880		Hamburg	"		— 3.06		———	
881		Petersburgh	"		+ 3.76		+ 5.55	
882	16	Cambridge, E.	"		— 2.68		———	
883		Cape G. H.	"		— 1.66		+ 1.12	
884		Durham	"		— 0.66		— 1.96	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					"		"	
885	1847. Sept. 16	Greenwich	Meridian		———		———	
886		Konigsberg	"		+ 1.00		+ 2.97	
887	17	Cambridge, E.	"		+ 1.39		+ 3.34	
888		Cape G. H.	"		— 3.09		+ 1.30	
889		Geneva	"		— 0.56		— 5.10	
890	18	Altona	"		+ 1.33		— 1.93	
891		Cape G. H.	"		+ 1.13		+ 0.83	
892		Christiania	"		— 1.60		+ 0.76	
893		Greenwich	"		— 2.53		+ 3.65	
894		Hamburgh	"		+ 1.73		+ 3.36	
895		"	"		+ 4.13		———	
896	19	Bonn	"		— 2.45		+3.29	
897		Cape G. H.	"		+ 0.09		———	
898		Kasan	Equatorial		— 0.00		———	
899		Geneva	Meridian		— 0.58		+ 0.04	
900		Hamburgh	"		— 1.84		+ 2.50	
901		Petersburgh	"		———		+ 2.67	
902	20	Altona	"		+ 2.59		— 2.56	
903		Cape G. H.	"		+ 2.40		+ 2.11	
904		Durham	Equatorial	*h*	+ 0.11	7	+ 1.21	7
905		Hamburgh	Meridian		— 0.81		+ 0.22	
906	21	Cape G. H.	"		— 2.95		+ 2.77	
907		Geneva	"		+ 3.44		+ 3.27	
908	22	Cape G. H.	"		— 2.46		+ 1.49	
909		Christiania	"		+ 1.02		+ 2.64	
910		Geneva	"		— 3.82		+ 2.90	
911	23	Bonn	"		— 0.16		+ 3.36	
912		Cape G. H.	"		+ 0.80		+ 0.38	
913		Geneva	"		— 3.42		— 2.41	
914	24	Cambridge, E.	"		+ 0.81		+ 4.63	
915		Christiania	"		+ 0.21		+ 1.23	
916		Greenwich	"		— 3.76		+ 1.18	
917	25	Cambridge, E.	"		+ 0.87		+ 3.26	
918		Cape G. H.	"		— 1.64		+ 1.18	
919		Greenwich	"		— 1.79		+ 0.36	
920		Petersburgh	"		— 0.25		+ 1.16	
921	26	Hamburgh	"		+ 2.74		+ 1.21	
922		"	"		+ 0.24		———	
923	27	Cambridge, E.	"		— 4 74		+ 3.05	
924		Greenwich	"		— 2.41		+ 2.01	
925		Hamburgh	"		— 1.64		— 0.02	
926	28	Cape G. H.	"		———		+ 1.42	
927		Christiania	"		+ 0.33		+ 1.10	
928		Durham	Equatorial	*h*	+ 2.18	6	+ 1.92	6
929		Geneva	Meridian		— 0.36		— 1.95	
930		Hamburgh	"		— 4.78		+ 0.58	
931	29	Cape G. H.	"		— 1.08		———	
932		Christiania	"		— 0.59		+ 1.61	
933	30	"	"		— 4.76		———	
934		Geneva	"		— 1.08		+ 3.31	
935	Oct. 1	Cape G. H.	"		+ 0.04		———	
936		Geneva	"		— 0.34		+ 0.90	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					″		″	
937	1847. Oct. 1	Konigsberg	Meridian		— 0.03		+ 0.47	
938	2	Geneva	"		— 1.41		— 2.50	
939	3	Cape G. H.	"		———		+ 2.48	
940		Christiania	"		+ 0.17		+ 0.68	
941		Geneva	"		— 3.82		+ 2 78	
942		Hamburgh	"		— 3.18		— 1.58	
943	4	Cape G. H.	"		— 2.42		+ 2.32	
944		Hamburgh	"		+ 0.67		+ 3.11	
945		"	"		+ 1.72		———	
946	5	Christiania	"		— 1.58		— 0.07	
947	6	Cambridge, E.	"		+ 0.95		+ 3.50	
948		Christiania	"		— 0.83		+ 1.94	
949		Petersburgh	"		— 1.13		+ 1.76	
950	7	Cambridge	"		— 0.07		+ 4.50	
951		Christiania	"		+ 0.43		+ 2.38	
952		Greenwich	"		— 2.68		+ 2.06	
953		Konigsberg	"		+ 0.62		— 1.96	
954	8	Cape G. H.	"		———		+ 0 50	
955		Durham	"		+ 1.84		+ 6.43	
956		Konigsberg	"		+ 1.44		+ 0.77	
957	9	Cape G. H.	"		— 0.28		———	
958	10	Kremsmunster	"		— 5.32		— 0.06	
959	11	Cambridge	"		— 4.30		+ 3.86	
960		Geneva	"		— 1.18		— 0.69	
961	12	Cambridge	"		— 2.18		+ 4.06	
962		Christiania	"		— 1.58		— 0.70	
963		Geneva	"		— 0.20		+ 0.11	
964		Hamburgh	"		— 1.92		— 2.85	
965		"	"		— 0.12		———	
966	13	Geneva	"		+ 0.01		— 4.36	
967	14	Hamburgh	"		— 4.47		— 1.47	
968	15	Christiania	"		+ 1.15		+ 0.27	
969		Gustau	Equatorial	*h & k*	— 3.64	3	+ 4.16	3
970		Hamburgh	Meridian		— 1.67		— 0.70	
971		Kremsmunster	"		+ 0.26		+ 3.16	
972	16	Cape G. H.	"		———		+ 0.37	
973		Gustau	Equatorial	*h & k*	— 0.48	3	+ 4.48	3
974		"	Meridian		+ 1.65		———	
975		Hamburgh	"		— 1.40		+ 0.10	
976		Kremsmunster	"		+ 0.23		+ 1.50	
977	17	Cape G. H.	"		— 1.26		———	
978		Hamburgh	"		— 0.25		+ 3.77	
979		Konigsberg	"		+ 1.34		+ 1.74	
980	18	Christiania	"		— 1.08		— 0.21	
981		Durham	"		— 5.23		+ 2.59	
982		Hamburgh	"		— 1.61		— 0.16	
983		Konigsberg	"		+ 0.80		— 0.27	
984	19	Cambridge, E.	"		— 2.94		+ 2.16	
985		Cape G. H.	"		+ 2.12		———	
986		Christiania	"		— 0.99		+ 1.52	
987		Greenwich	"		— 0.90		+ 0.84	
988		Konigsberg	"		+ 0.07		+ 1.15	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					″		″	
989	1847. Oct. 20	Cambridge, E.	Meridian		— 3.41		+ 3.07	
990		Cape G. H.	"		— 2.04		———	
991		Christiania	"		— 0.53		+ 2.56	
992		Kremsmunster	"		———		— 2.44	
993	21	Cambridge, E.	"		— 3.98		+ 1.80	
994		Cape G. H.	"		— 0.42		— 0.50	
995		Durham	Equatorial	g	———	4	+ 5.08	4
996		Greenwich	Meridian		— 3.12		+ 1.39	
997		Petersburgh	"		+ 4.99		+ 1.41	
998	22	Cape G. H.	"		— 1.91		———	
999		Geneva	"		+ 1.08		— 6.33	
1000		Hamburgh	"		———		+ 1.84	
1001		Konigsberg	"		+ 0.17		+ 1.61	
1002		Kremsmunster	"		+ 2.86		— 1.51	
1003		Petersburgh	"		— 0.35		+ 1.06	
1004	24	Cape G. H.	"		+ 0.24		———	
1005		Christiania	"		+ 0.85		+ 1.44	
1006		Hamburgh	"		— 1.13		— 2.93	
1007		"	"		+ 1.27		———	
1008	25	Cambridge, E.	"		+ 0.38		+ 1.34	
1009		Cape G. H.	"		— 0.78		———	
1010		Christiania	"		— 1.97		— 1.50	
1011		Hamburgh	"		+ 0.96		— 2.18	
1012		"	"		+ 1.96		———	
1013		Makerstoun	Equatorial	h	— 3.11	5	— 1.98	5
1014	26	Cambridge, E.	Meridian		+ 0.19		+ 2.23	
1015		Cape G. H.	"		———		+ 0.15	
1016		Christiania	"		— 2.56		— 1.78	
1017		Geneva	"		— 0.12		+ 0.26	
1018		Greenwich	"		— 1.20		+ 0.10	
1019		Hamburgh	"		— 4.25		— 1.74	
1020		"	"		— 5.20		———	
1021	27	Cape G. H.	"		— 1.93		———	
1022		Durham	"		— 0.80		+ 4.87	
1023		"	Equatorial	h	— 1.35	6	+ 3.02	6
1024		Hamburgh	Meridian		— 5.88		— 1.86	
1025		Konigsberg	"		+ 2.45		+ 2.05	
1026		"	Heliometer	i	— 0.84		+ 0.56	
1027		Makerstoun	Equatorial	h	— 0.63		— 1.69	
1028	28	Cape G. H.	Meridian		— 1.03		+ 1.41	
1029		Christiania	"		— 0.85		— 0.36	
1030		Durham	Equatorial	h	+ 2.84	6	+ 4.09	6
1031		Hamburgh	Meridian		— 2.38		+ 3.03	
1032		Makerstoun	Equatorial	h	— 0.13		— 2.67	
1033	29	Cape G. H.	Meridian		— 4.30		———	
1034		Hamburgh	"		+ 0.14		+ 0.22	
1035		Makerstoun	Equatorial	h	— 2.02		— 0.18	
1036	30	Cape G. H.	Meridian		— 1.28		+ 2.29	
1037		Christiania	"		+ 0.30		— 1.72	
1038	31	Copenhagen	"		— 1.82		———	
1039	Nov. 1	Cambridge, E.	"		+ 0.73		+ 3.29	
1040		Cape G. H.	"		— 3.37		———	

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Mea-sures.	Δ δ	Mea-sures.
					″		″	
1041	1847. Nov. 1	Geneva	Meridian		+ 1.67		— 1.83	
1042		Greenwich	"		— 1.68		+ 0.27	
1043		Konigsberg	"		— 1.50		+ 4.65	
1044	2	Altona	"		+ 0.45		— 0.86	
1045		Cambridge, E.	"		+ 1.29		+ 1.92	
1046		Durham	Equatorial	*h*	— 8.16	2	+ 1.71	2
1047		Hamburgh	Meridian		+ 5.05		— 1.87	
1048		"	"		— 4.15		———	
1049		Konigsberg	"		— 1.10		— 1.88	
1050	3	Bonn	"		— 2.01		+ 1.05	
1051		Christiania	"		+ 0.65		— 0.10	
1052		Konigsberg	Heliometer	*i*	— 1.31		+ 0.96	
1053		"	"	*k*	+ 0.01		+ 0.10	
1054		Petersburgh	Meridian		— 0.90		+ 0.20	
1055	4	Cape G. H.	"		— 1.51		———	
1056		Christiania	"		— 3.11		———	
1057		Petersburgh	"		+ 0.08		+ 1.27	
1058	5	Cape G. H.	"		— 4.31		+ 0.79	
1059		Bonn	"		— 0.13		+ 2.30	
1060		Konigsberg	"		— 0.78		+ 0.99	
1061	6	Cape G. H.	"		— 4.36		+ 0.33	
1062		Bonn	"		— 1.11		+ 2.62	
1063		Konigsberg	Meridian		+ 0.40		+ 2.01	
1064		"	Heliometer	*i*	— 0.77		+ 1.08	
1065		"	"	*k*	— 0.84		— 0.66	
1066	7	Cape G. H.	Meridian		— 0.28		———	
1067		Konigsberg	"		+ 4.95		+ 1.68	
1068	8	Cape G. H.	"		— 1.02		———	
1069		Gustau	"	*h & k*	+ 4.07	3	+ 0.66	3
1070		Makerstoun	Equatorial	*h*	— 0.34	8	— 1.91	8
1071	9	Durham	"	*h*	— 1.56	8	+ 2.46	8
1072		Geneva	Meridian		+ 7.94		— 6.84	
1073		Konigsberg	"		+ 1.78		+ 0.57	
1074		Makerstoun	Equatorial	*h*	— 0.55	8	— 2.47	8
1075	10	Altona	Meridian		— 1.65		— 0.82	
1076		Bonn	"		+ 1.16		+ 1.67	
1077		Cambridge, E.	"		— 2.62		+ 1.98	
1078		Geneva	"		+ 4.71		———	
1079		Greenwich	"		— 0.35		+ 1.97	
1080		Hamburgh	"		— 5.25		+ 1.57	
1081	12	Makerstoun	Equatorial	*h*	— 0.69	3	— 1.01	3
1082		Gustau	"	*h & k*	+ 2.12	3	+ 2.54	3
1083	14	Georgetown	Meridian		+ 1.33		+ 3.71	
1084	15	Cambridge, E.	"		— 0.92		+ 1.49	
1085		Georget'n, D.C.	"		— 1.30		+ 5.55	
1086	16	Cambridge, E.	"		— 6.62		— 1.89	
1087		Christiania	"		+ 0.38		+ 1.65	
1088		Copenhagen	"		+ 1.51		———	
1089		Makerstoun	Equatorial	*h*	+ 0.69	10	— 1.45	10
1090	17	Christiania	Meridian		— 2.74		+ 2.19	
1091		Copenhagen	"		+ 1.99		———	
1092		Durham	Equatorial	*h*	— 1.72	5	+ 2.96	5

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc.)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Mea-sures.	Δ δ	Mea-sures.
					"		"	
1093	1847. Nov. 27	Hamburgh	Meridian		— 0.44		— 0.02	
1094		Makerstoun	Equatorial	*h*	+ 1.70	4	— 1.73	4
1095	18	Altona	Meridian		+ 3.02		— 0.60	
1096		Cambridge, E.	"		———		— 0.28	
1097		Copenhagen	"		+ 2.19		———	
1098		Greenwich	"		+ 0.54		+ 1.06	
1099		Hamburgh	"		+ 2.62		+ 1.80	
1100		"	"		+ 4.12		———	
1101	19	Cambridge, E.	"		— 0.85		+ 2.66	
1102		Durham	Equatorial	*h*	+ 1.45	2	+ 2.15	2
1103	20	Christiania	Meridian		— 1.15		— 0.85	
1104	21	Hamburgh	"		+ 0.15		+ 1.99	
1105		"	"		— 3.85		———	
1106	23	Cambridge, E.	"		— 0.60		— 0.01	
1107		Christiania	"		— 3.98		+ 4.17	
1108	24	Altona	"		+ 1.60		+ 0.76	
1109		Cambridge, E.	"		+ 0.78		+ 1.09	
1110		Geneva	"		+ 4.28		— 5.96	
1111		Greenwich	"		— 1.31		+ 0.62	
1112		Hamburgh	"		— 2.40		— 0.54	
1113	26	Christiania	"		— 0.96		+ 3.12	
1114	27	Hamburgh	"		— 0.92		+ 1.20	
1115		"	"		+ 2.28		———	
1116		Konigsberg	"		— 0.83		— 0.21	
1117		"	Heliometer	*l*	— 0.20		+ 1.70	
1118		"	"	*k*	— 0.16		+ 0.98	
1119	28	Hamburgh	Meridian		— 2.54		+ 2.82	
1120		"	"		— 5.54		———	
1121		Konigsberg	"		———		+ 2.32	
1122	29	Cambridge, E.	"		+ 2.11		+ 2.33	
1123		Georget'n, D.C.	"		— 3.36		+ 3.16	
1124		Greenwich	"		— 0.53		+ 4.59	
1125	30	Geneva	"		+ 3.79		———	
1126	Dec. 1	Cambridge, E.	"		— 0.41		+ 2.20	
1127		Greenwich	"		— 0.21		— 0.47	
1128	3	Makerstoun	Equatorial	*h*	+ 1.43	6	— 1.40	6
1129	4	Hamburgh	Meridian		— 0.22		— 0.07	
1130		"	"		+ 4.12		———	
1131	6	Cambridge, E.	"		+ 0.74		+ 2.32	
1132		Greenwich	"		— 0.15		+ 3.97	
1133	8	Cambridge, E.	"		+ 3.74		+ 2.83	
1134		Hamburgh	"		— 0.44		— 0.07	
1135	9	Konigsberg	Heliometer	*i*	— 0.37		+ 1.72	
1136		"	"	*k*	— 0.33		+ 1.00	
1137	10	Geneva	Meridian		— 1.36		— 0.73	
1138	12	Hamburgh	"		— 2.19		+ 1.68	
1139		"	"		+ 2.01		———	
1140		Konigsberg	"		— 2.67		+ 0.88	
1141	13	Cambridge, E.	"		— 3.36		+ 2.97	
1142		Greenwich	"		— 2.99		+ 1.84	
1143	14	Gustau	Equatorial	*h & k*	+ 2.33	3	———	
1144	15	"	"	*h & k*	+ 3.36	3	— 1.85	3

OBSERVATIONS OF NEPTUNE.					OBSERVATION—EPHEMERIS.			
					In R. A., (arc)		In Declination.	
No.	Date.	Observatory.	Instrument.	Star.	Δ α	Measures.	Δ δ	Measures.
					"		"	
1145	1847. Dec. 17	Hamburgh	Meridian		— 1.36		— 3.63	
1146		Konigsberg	"		———		+ 1.86	
1147	18	Gustau	Equatorial	*h & k*	+ 4.56	3	— 2.25	3
1148	19	Konigsberg	Meridian		— 2.68		+ 1.31	
1149	24	Gustau	Equatorial	*h & k*	+ 2.09	3	— 4.42	3
1150	25	Konigsberg	Heliometer	*f*	— 0.56		+ 0.97	
1151	1848. Jan. 9	Hamburgh	Equatorial		+ 2.05		———	
1152	11	Durham	"	*f*	+ 1.34	3	+ 2.57	3
1153	12	Cambridge, E.	"	*f*	— 0.30	4	— 2.47	4
1154	15	"	"	*f*	+ 3.47	6	— 0.35	6
1155	16	Hamburgh	"		———		+ 0.90	
1156	27	Cambridge	"	*f*	+ 3.18	3	———	3

This list includes all the standard observations of Neptune, to the end of January, 1848, as far as received.

It is proposed to resume the series at a future occasion.

Yours, respectfully,

SEARS C. WALKER.

WASHINGTON, *April* 10, 1848.

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

ON THE

VOCAL SOUNDS OF LAURA BRIDGEMAN,

THE BLIND DEAF-MUTE AT BOSTON;

COMPARED WITH THE ELEMENTS OF PHONETIC LANGUAGE.

BY FRANCIS LIEBER.

VOL. II. ART. 2.

THE NAMES

OF THE COMMISSION TO WHICH THIS MEMOIR HAS BEEN REFERRED.

Col. W. W. S. BLISS,
D. L. DIX.

JOSEPH HENRY,
Secretary.

A PAPER

ON THE

VOCAL SOUNDS OF LAURA BRIDGEMAN,

THE BLIND DEAF-MUTE AT BOSTON;

COMPARED WITH THE ELEMENTS OF PHONETIC LANGUAGE.

BY FRANCIS LIEBER.

Language consists of signs, representing ideas. These signs are selected by the person who speaks in accordance with the ideas prevailing in his own mind, in order to produce the reversed process in the individual spoken to; that is, they are used for that process—the most wonderful and most important on this earth—of conveying ideas from one distinct individual to another; for the communion of mind with mind, through sensuous impressions, made in skilful succession, and in accordance with general laws. Why, then, do all languages consist of phonetic signs? There is no tribe known making exclusive use of ocular communion, or conveying ideas chiefly by visible signs. Yet the eye conveys to the mind perceptions far more varied and enriching than all the other senses, and is an organ which, bating the developed phonetic language itself, contributes infinitely more to the formation of the mind than the sense of hearing. If persons who do not understand each other's languages, nevertheless must commune, a wrecked sailor, for instance, with an inhabitant of a foreign shore, they generally take, first of all, refuge in ocular signs. The Rev. Mr. Gutzlaff tells us that the Chinese accompany their speech with a great many visible signs, without which the audible ones cannot be understood.* The orators of all nations accompany their spoken words with signs intended for the eye, in a greater or less degree, voluntarily or impulsively, naturally or artistically. Why, then, do we find nowhere a regularly, or logically developed ocular language? It is no sufficient answer that the phonetic signs uttered by the

* The Chinese have even the belief that there is a word expressive of all excellence, and so exquisite, that no one can pronounce it; but that it can only be written, or be perceived by the eyes. The sixth of Dr. Blair's Lectures on Rhetoric and Belles Letters, may be read, with reference to this subject, not without profit.

infinitely pliable organs of the human voice present a greater variety than all those that can be produced by the other organs. We are, indeed, able to make this discovery now, when all the riches and infinite blessings of a phonetic language are spread before us; but how was man led to develope these riches, when, as we have seen, he first of all resorts to ocular signs, and stands in need of them even after he has been possessed of all the wealth of auricular language? Had God left it to the invention of man, before he could know to what amount of utility, enjoyment, refinement, affection, elevation, thought and devotion his phonetic communion, and its representative in writing, would lead, man could never have attained to the prizes of language and literature. But Providence, in this as in all other elements of civilization, has, by organic laws of our nature, forced men into that path by which alone their starting in the career of progress can be unfailingly secured—by laws which oblige man to set out in the right direction.

A clearer insight into the phonetic origin of human language is important both to the philosopher and the physiologist. Besides, all appreciation of truth conduces to a purer state of the mind, a wider spread of knowledge, and, ultimately, to an intenser devotion to God. It is my object to give in this paper a contribution to this great inquiry, for which the vocal sounds of Laura Bridgeman, a female endowed with a peculiarly active mind, but deprived from earliest infancy of sight and hearing, and nearly destitute of taste, seem to offer a singularly fit opportunity.

I have always read with attention the annual reports of Dr. Howe on the education of this most interesting being, by which he has already acquired imperishable renown in both hemispheres. From year to year I have been in the habit of visiting Laura and her sagacious teachers, who, as every one is aware, have succeeded in giving language, the power of verbal thought, and the means of intellectual and moral development, to a being who seemed to be shut up within the loneliest prison-house that our minds can conceive of; apparently walled up, without one means of communion with the world, and possessed only of one solitary channel of distinct perception—the confined sense of touch.

At length I passed three entire months in the immediate neighborhood of Laura, saw and observed her daily, while every possible facility was extended to me by Dr. Howe and his assistant teachers. Among other things, I paid attention to her vocal sounds.

In order to be better understood in the following pages, and to prevent misunderstanding on some material points, I would refer to a lecture of mine on the origin of the first constituents of civilization;* especially so far as the origin of language is concerned, to pages 14 to 18. To what has been said there I would add the following observations:

The origin of all utterance is emotional. This applies to man and brutes; but utterance soon acquires in man a very different character. With the animal

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* Published in 1845.

it remains forever almost exclusively emotional; in some rare cases it approaches the character of language.

All emotion excites the nervous system, or consists in an excitement of the nervous system. which, so long as we remain in the body, is linked to the mind by such mysterious laws. This excitement becomes apparent by a variety of phenomena. A person in joyful surprize before a Correggio, exclaims "Ah!" and quickly brings both hands together: an irritable person says, "Come here, I say," rapping the table in quick succession, beating repeatedly the floor with his foot, and knitting his brows with the contraction of impatience: a frightened dog runs howling away, and drops the ears and tail; or, however lazily he may be lying on the ground, he slightly moves the tip of the tail at hearing his master's footsteps: an orator winds up by saying, "But the people will suffer it no longer," opening wide his eyes, shaking his lifted right hand, moving his head with an inclination of his whole person, and pronouncing his words slowly, solemnly, and in a deep tone: a hungry cat, sitting by the table, utters plaintive sounds, and looks steadily at the child who is in the habit of feeding it, moving one of the forepaws, as if in the act of grasping something. All these respective signs which accompany the utterances, and the utterances themselves, are phenomena arising in each case from one and the same cause. I would call them, therefore, symphenomena—a legitimate word, it seems, both in point of etymology and meaning. Our accent, our intonation, our gestures, the shrugging of the shoulders, the opening wide or half-shutting of the eyes, the curling of the lip, the pointing involuntarily at objects, the rubbing the head in cases of perplexity, the accompanying our words by depictive signs, laughing, blushing, smiling, weeping, moaning, with hundreds of other phenomena, are symphenomena of the idea or emotion prevailing at the time within us, and affecting the brain and nervous system. I would call, then, symphasis the manifestation of two or more phenomena conjointly produced by the same cause.

It will appear at once how important the whole subject of symphany is, when we consider that that which is originally the pure symphenomenon of an emotion, becomes, in the beholder, who cannot know of the emotion by direct communion from mind to mind, a *sign*, indicating or *conveying* the emotion from the original sentient to his fellow-creature. Crying, wringing the hands, and uttering plaintive sounds, are the spontaneous symphenomena of despair. He in whom they appear does not intentionally produce them. He, however, who beholds them, knows them, because they are spontaneous, and because he is endowed with the same nature and organization; and thus they become *signs* of despair. Henceforth rational beings may intentionally *produce* them, when they *desire* to *convey* the idea of despair. There is no invention in this case; no conventional agreement upon an arbitrary sign; but there is, nevertheless, a development of a sign by rational beings out of that which they, at first, produced involuntarily as sentient creatures. The latter man has in common with the brute. The animal world is full of symphenomena. The first, however—the transformation of the symphenomenon into an intentional sign—belongs to the

defining, generalizing, and combining power of reason. The nursery, that spot where the history of mankind is lived over again in more than one respect, furnishes us with many instances of this important process.

The theory of symphany finds a wide and, I conceive, a fruitful application in many different branches of moral and physical knowledge; but we have to deal with it here so far only as it affects the origin of phonetic language, and the vocal sounds of Laura Bridgeman.

Symphenomena show themselves in all of us. Art even cultivates them, and draws them within the sphere of studied elocution. But they are most observable with untutored beings—with children and uncivilized tribes; or with the educated adult, when deep emotion breaks through the tranquil repose which is the general characteristic of cultivated life. Every one knows how vehement the expressions of grief, joy, despondency, love or revenge, are with savages, or how a sudden calamity at sea produces all the symphenomena in their native and unrestrained variety in polished men or women. "Kiss me, Hardey—kiss me," exclaimed Lord Nelson, when Captain Hardey had told him that the shout which the admiral had heard was that of victory, and he felt his life rapidly ebbing away.

As a matter of course, these symphenomena appear strongly in Laura Bridgeman; and, if unrestrained, will show themselves at times so forcibly as to be distasteful to others. They were therefore restrained by her teachers, for the same reason that we often check them in children. The object of Laura's education was to make her fit for social intercourse; and the vehement demonstrations of symphenomena would have interfered with this noble and important object.

It is necessary here to guard against a possible misunderstanding of the preceding words. Some readers may suspect that it has been difficult to restrain this blind deaf-mute, on the score of decorum, because she can have conceived no idea of good breeding by constant and involuntary observation of the well-bred around her, as we do from our earliest infancy. Yet, remarkable as the fact may be, Laura has at no time of her life failed against the nicest delicacy. We have the word of all her teachers for this surprizing fact; and every one who has had an opportunity of observing her will agree with me, that her conduct is marked throughout by a delicate feeling of propriety. I confess that this is very remarkable, when we consider the offensive conduct of many savage tribes; but it only shows that delicacy of behavior and propriety of demeanor are natural to man, though they may not be always primitive. They require development, like most things which are essentially natural to the mind and soul of man. This development may be individual, or it may belong to the tribe, the race, and yet may have become more or less inherent.

Laura not only blushes and weeps, laughs and smiles, which may be called absolute or direct symphenomena, requiring no more an act of aiding volition than the throbbing of the heart does; but I have seen her stamping with joy—an impulsive phenomenon which we observe in a more regulated form, brought

under the influence of volition (as the original impulsive tone is at a later period voluntarily pronounced as a word) in the form of applause in large assemblies. When Laura was speaking to me* of a cold bath, the idea prevailing at the time in her mind produced the motion of shivering. This was, for her, purely symphenomenal; but it became to me, who was looking at her, a sign, or symbol, because it expressed the effect which the cold water had produced on her system.

When Laura is astonished, or amazed, she rounds and protrudes her lips, opens them, breathes strongly, spreads her arms, and turns her hands with extended fingers upwards, just as we do when wondering at something very uncommon. I have seen her biting her lips with an upward contraction of the facial muscles when roguishly listening at the account of some ludicrous mishap, precisely as lively persons among us would do. She has not perceived these phenomena in others; she has not learned them by unconscious imitation; nor does she know that they can be perceived by the by-stander. I have frequently seen her, while speaking of a person, pointing at the spot where he had been sitting when Laura last conversed with him, and where she still believed him to be, as we naturally turn our eye to the object of which we are speaking. She frequently does these things with one hand, while the other receives or conveys words. When Laura once spoke to me of her own crying, when a little child, she accompanied her words with a long face, drawing her fingers down the face, indicating the copious flow of tears; and when, on New Year's day of 1844, she wished in her mind a happy new year to her benefactor, Dr. Howe, then in Europe, she involuntarily turned toward the east, and made with both her outstretched arms a waving and blessing motion, as natural to her as it was to those who first accompanied a benediction with this symphenomenon of the idea, that God's love and protection might descend in the fulness of a stream upon the beloved fellow-being. This movement, though solemn, was as spontaneous with Laura as another of a ludicrous character was to a lively Italian, who told me, at Rome, that a friend on whom I called had just left the house on horseback, and accompanied the words by putting two fingers of the right hand astride on the digit of the left. He had no fear that I might not understand him, for he was freely conversing with me. With both, the gestures were simply symphenomena of the ideas entirely occupying their minds at the time.

A young lady to whom Laura is affectionately attached has a short, delicate, and quick step, which Laura has perceived by the jar "going through the feet

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* For those wholly unacquainted with Laura's case I will simply state, that Dr. Howe has succeeded in imparting to her a finger-language, or, to speak more correctly, finger-writing. She knows the value of words, and freely communes with every one who knows her finger-alphabet, which is formed in each other's hand. Her alphabet corresponds to our phonetic alphabet, although it represents no sound to her, but consists of signs of the touch, as the letters which the deaf-mute learns and reads are exclusively ocular signs, and have no phonetic value for him.

up to the head," as she very justly describes it. One day she entered the room, affecting the same step; and when asked by the young lady why she did so, she promptly replied, "You walk thus, and I thought of you." Here the question made her conscious that her imitative step was a symphenomenon, and nothing more, of the idea of that young friend of hers, then uppermost in her mind.

On page 37 of Dr. Howe's tenth report, we find the account of a conversation between Laura and one of her teachers on an insect. Laura asked, "Has he think?" touching at the same time her forehead—(for a reason similar to that by which Dr. Spurzheim explained the fact, that Sterne's portrait represents him pointing unconsciously to the spot which the phrenologists believe to correspond to the organ of wit.) Laura continued to ask, "Does he breathe much?" at the same time putting her hand on her chest and breathing hard. On page 44 of the thirteenth report, an account is given of Laura's relation of a dream. She said, "I dreamed that God took away my breath to heaven," accompanying her words with a sign of taking something away from her mouth. Who can help remembering here the fresco paintings of the Campo Santo, at Pisa, where, with an equally infantine conception of the removal of human souls, angels are represented drawing the souls out of the mouths of the dead? Or who does not at once recollect the many languages, ancient and modern, in which breath and spirit are designated by the same word?

In none of these cases does the remarkable girl, blind, deaf and dumb, as she is, intend to illustrate by gesture, or any other sign, the meaning of her words, no more than we do by most of our gesticulations, frowns, smiles, or other expressions, which, indeed, we often show unconsciously; so much so, that they actually betray us. In one word, they are, as has been repeatedly said, symphenomena.

But the symphenomena of an agitated mind, or of strong affections, show themselves most readily, and in the greatest variety, as effects of the respiratory organs, because these are most easily affected, being of a peculiarly delicate character; because the voice can be modulated almost without end; and because, in fact, comparatively few affections suggest images to be imitated by ocular signs. Strong emotion requires exterior manifestation: it will out, to use a colloquial term, and utterance of some sort is the consequence. We have this process in common with the brutes; but the affections of the latter are circumscribed, and their organs of utterance infinitely more limited than those of man. Uncouth, or, at any rate, inarticulate sounds are uttered by man before his lip is blessed with the rational word, or his mind with verbal thought, and man falls back upon the inarticulate sounds when his emotion overflows the usual channels of expression—when unspeakable love or convulsive wrath, stunning fear or transcending admiration, overpowers him. A parent who clasps his lost child again within his arms; a person who beholds the sea for the first time; a man suddenly insulted to the quick by stupendous falsehood; a maiden to whom, unwarned, a hideous death presents itself—these are not apt to give utterance in words, but they breathe forth their emotions in primitive and inar-

ticulate sounds. I once heard a colored preacher describing the torments of future punishment. He rose, not ineloquently, from the description of one anguish to another, when at last, carried away by uncontrollable excitement, he merely uttered, for more than a minute, a succession of inarticulate sounds or cries.

Where, however, is the limit between articulate and inarticulate sounds? What is articulation?

I believe that, unconsciously, we generally consider sounds articulate when, while we hear them, the mind can spell or trace them with our accustomed alphabet. The clucking tones of some savages, the pure guttural sounds of others, and those sounds which we cannot even indicate by a name, appear to the missionary, who first hears them, as inarticulate, because he does not hear in them the elements, called letters, to which he is accustomed. Yet these sounds belong to languages, and are undoubtedly articulate. William von Humboldt, on the other hand, says that we cannot give any other definition of articulate sounds than that they are those sounds which man intentionally utters in order to convey something thought. This seems to me equally erroneous. Thoughts and feelings may be expressed, though intentionally, without articulate sounds; and, however true it be, that we almost always express our thoughts by articulate sounds, still the meaning of the term *Articulation* must be sought first of all in the sound itself. Now we can give no other definition of an articulate sound than that it is an *unbroken* emission of a sound which is composed of those elements for which we have not even a befitting name when uttered, but which, when written, are called *letters*, and which are exclusively belonging to the human organs of speech. Such sounds are called articulate, because their succession divides or articulates the human speech into one-sounded parts—into joints or single emissions, called syllables. These distinct sounds, their combinations and repetitions, make it possible for man to have a phonetic language, or a system of sounds by which he can convey ideas, and, so far, there exists the closest connexion between *Reflection* and *Articulation*, between *Thought* and *Word;* but there can be articulation without distinct thought or intended conveyance of ideas, as was the case in that remarkable instance of the sound *Titnoss*, of which mention will be made in a future note.

Neither these, nor any remarks contained in the present memoir, have been made to deny the close connexion between thought and word. So soon as man has a distinct idea, he feels the yearning to speak it out, and if he has a distinct idea of a single thing he longs to name it. This seems to be the chief meaning of the 19th verse of the second chapter of Genesis. The necessity and longing to name animals is placed thus early in the history of the creation, and this implanted yearning is expressed in the remarkable line which says that the Creator led the animals to Adam "*to see what he would call them.*" By a natural transposition, words are ascribed to animals so soon as we imagine them with distinct thoughts similar to our own, as the early fable shows. I was looking lately at a negro who was occupied in feeding young mocking birds by

the hand. "Would they eat worms?" I asked. The negro replied: "Surely not; they are too young; *they would not know what to call them.*" A singular commentary, almost touching in its simplicity, on the passage in Genesis to which allusion has been made.

Observation shows us that every emotion quickens the respiration, or causes an oppression of the chest, which seeks relief by violent inhaling. This is the origin of our sighs, laughter, moaning, and those exclamations of Ah, Eh, Oh, which are gradually cast into articulate sounds, and many of which become regular words, classified according to systematic grammar, such as alas, helas, pooh, bah, umph, pshaw, ototoi, ecco, ecce, halloo, huzzah, and of which we have so remarkable an instance in Sophocles, who makes Philoctete exclaim—

"Attatai, ototlotoi apappapai, papa, papa, papa, papai!"

And in Dante's:

"Pape Satan, pape Satan, alleppe!"

Laura utters a loud sound of *o*, with a strong aspirate, inclining almost to the sound *f*, which might be written somewhat in this manner, "Ho-o-ph-ph!" when she is highly excited by wonder. We do the same when the laws of propriety do not prevent us from giving vent to our feeling of amazement. And the actor of the broad farce accompanies his assumption of stupid surprise with the same exclamation, because, in his endeavor to caricature, he stands in need of the imitation of strongly marked symphenomena.

Frequently I have heard Laura expressing a feeling of satisfaction by a subdued tone, somewhat between chuckling and a slight groaning.*

Utterance, produced by increased activity of the respiring organs, and varied by the pliable vocal organism, and the great moveability of the lips and tongue, is so direct and natural an effect of the excited nervous substance, that sounds of grief, pain, affection, disgust, contempt, despair, pity, fear, attention, admiration, mockery, surprise, wrath, entreaty, delight, approval, caution, or submission, are as natural even to us, tutored and trained as we are from early infancy, both by positive instruction and the ever active imitative principle, as are the wholly spontaneous symphenomena of growing pale or wringing the hands. Laura actually once, when reminded by one of her teachers that she ought not to indulge in her uncouth sounds, which resemble those made by deaf-mutes, answered, "I do not always try not to make them." The teacher urged the reasons why it is desirable she should restrain them, and was answered, "But I have very much voice." Laura went farther, and added, "God gave me much voice;" thus strikingly pointing out a truth of elemental importance to the philosopher. Yielding, however, to the arguments against this "voice," she

* I would have said *grunting*, as more accurately expressing the sound, had I not felt reluctant to use this word in connexion with that amiable and delicate being.

will at times go into her closet, and shutting her door, "indulge herself in a surfeit of sounds." (Page 27 of thirteenth report.) This seems to me not only very interesting and instructive, but also deeply touching.*

A missionary of my acquaintance, whose word I noways doubt, informed me that one day he was travelling in the distant West of our Union with a young man who was greatly pleased with something that had been said. Becoming excited, the young traveller asked his friend to excuse him for a moment, whereupon he uttered a tremendous yelling. This done, he declared that the indulgence had done him much good, and the thread of the conversation was resumed. Nor will any one feel disposed to doubt the truth of this account, who is acquainted with the shouts which the less educated of the thinly peopled parts of the West and South set up on all occasions of any excitement; not only at barbacues, but even when a few persons are met, and something considered peculiarly laughable or "smart" has been said. When poor Laura retires into her closet, freely to revel in her sounds, she only does what we ourselves do when we have checked our desire to laugh, but indulge in it so soon as we find ourselves alone, or in presence of those persons only before whom we do not feel obliged to repress the symphenomenon. Indeed, Laura does no more, although in inarticulate sounds, than we do when, thoroughly impressed with some feeling, we speak to ourselves where no one can hear us. And it may be remarked, that the least tutored are most given to these soliloquies. There are many negroes in the South upon whom it is utterly impossible to impose silence when they are in a state of excitement, though they may not speak to any one, and may not be actuated by any feeling of opposition.

I ask permission to mention here a fact, which has always appeared to me very remarkable, although I own it does not relate to Laura's vocal sounds. I may not have another opportunity to place it on record, and am convinced that it deserves being known. Laura constantly accompanies her *yes* with the common affirmative nod, and her *no* with our negative shake of the head. Both are with her in the strictest sense primitive symphenomena of the ideas of affirmation and negation, and not symphenomena which have gradually become such by unconscious imitation, as frequently may be the case with us. The nodding forward for assent, and the shaking of the head or hand from side to side for dissent, seem to be genuine symphenomena accompanying these two ideas. Assent and dissent are closely allied to the ideas of favor and disfavor, which are naturally accompanied by an inclination toward, or a turning from, the real or ideal object. The very word *aversion* points to this symphenomenal fact. When we signify assent or dissent with the hand, a similar sign is observed.

The Italians move repeatedly the lifted digit from right to left, as a sign of negation, while the modern Greeks throw back the head, producing at the same time a clucking noise with the tongue. Laura makes at present these signs, even without writing a Yes or No in the hand of the person with whom she

*She will also, when deeply grieving, shut herself up, and seek comfort in unrestrained weeping.

converses, having learned, but not having been told, that somehow or other we perceive this sign, or that it produces upon us the desired effect, although she is unable to solve the great riddle of the process by which this is done. Laura, far below our domestic animals, so far as the senses are concerned, but infinitely above them because she is endowed with a human mind, has attained to the abstractions of affirmation and negation at a very early age, while no dog or elephant, however sagacious, has been known to rise to these simple ideas, for which every moment even of animal existence calls, wherever reflection sways over the naked fact.

Laura, then, independently of sight and hearing—the two most suggestive senses in every thing that appertains to language—felt an impulsive urgency to utter sounds as symphenomena of emotions, or vivid ideas, in common with all those human beings who have not attained to a language properly so called; but at the very outset she met with the following obstacles:

Laura cannot hear her own voice; nor can she perceive the tones of others. She could not, therefore, learn to modify, vary, and articulate them according to a developed language, which is the successive work of many and long periods of civilization. How much our tones, in their infinite and significant modulations, owe to the fact that we move in a speaking society from earliest infancy, becomes manifest, when we consider the uncouth, broken, and animal sounds of the lowest savages, and, on the other hand, that even the utterances of the brute are modified by their intercourse with man. Mr. Jesse, in his Anecdotes of Dogs, London, 1846, ascribes this effect of the never-ceasing and ever-varying hum of civilization to these animals. "It is," he says, "I believe, a fact, and if so a curious one, that the dog in a wild state only howls; but when he becomes the friend and companion of man, he has, then, wants and wishes, hopes and fears, joys and sorrows, to which in his wilder state he appears to have been a stranger. His vocabulary, if it may be so called, then increases, in order to express his enlarged and varied emotions." Of course Mr. Jesse cannot mean by the words "in order to express," anything like inventive purpose on the part of the dog, but he must mean a combined effect of the widened circle of emotions in the animal, and the multiplied sounds of civilization which surround it, especially of the master's language or other tones addressed to it.

The second great obstacle for Laura was, that she did not perceive the effect produced, in each case, by her sounds upon others. The idea of a specific force and value of a certain sound, which directly leads to the conception of the name or word, and facilitates all the means of designation, and of combining these means, could not easily, and never perfectly, appear to her. I shall presently dwell more at length upon this point.

Lastly, Laura was positively interrupted in the formation even of her imperfect and elementary phonetic language, as I have stated before, in order to make her a being of intercourse in our society—in order to attach her as a living member to the community of civilization. This could not have been done had she been allowed freely to indulge in the harsh and grating sounds which

excited souls utter forth through a throat, untaught and unbred, so to say, by the harmony of developed civilization in which we move.

I have already alluded to the distinction which we ought to make between merely spontaneous symphenomena and those which may be called secondary; that is, such as have become involuntary symphenomena by habit. If there was such a word as *habital*, I would use it as a more appropriate term for secondary symphenomena.

The exclamation of sudden pain is one of the first class; speaking loudly with ourselves, when there is no one in our hearing, and when, perhaps, we would not wish to be overheard, and the speaking in our dreams, are instances of the second class. These secondary, or habital symphenomena, are also observed in Laura. She does not only frequently talk to herself with one hand in the other, waking or in her dreams, which is likewise seen with deaf-mutes who have been taught the finger alphabet; but Laura, who has, as will be presently shown, certain particular sounds for distinct persons—names, or nouns proper, if we choose to call them so—utters these name-sounds for herself when she vividly thinks of these individuals. Dr. Howe's tenth report, page 30, contains the following passage:

"Laura said to me, in answer to a question why she uttered a certain sound, rather than spelled the name, 'I think of Janet's noise; many times when I think how she give me good things I do not think to spell her name.' And at another time, hearing her in the next room make the peculiar sound for Janet, I hastened to her, and asked her why she made it. She said, 'Because I think how she do love me much, and I love her much.'"*

It cannot be fairly objected that, if all that I have stated be true, it would lead to the inference that the deaf-mutes, and even the blind deaf-mutes, must be able to attain to a complete phonetic language. For, I have spoken only of the impulsive utterances which form the incipient elements of language, natural to the deaf and blind as they are to the hearing and seeing, and out of which words proper, with all their changes, combinations, and inflections, can be evolved only by constantly repeated and enduring vocal intercourse. Yet, it will be interesting carefully to inquire how far Laura Bridgeman—blind and deaf, indeed, but endowed with a sprightly and delicate mind, and an affectionate soul—actually possesses the elements of our vocal language.

For this purpose we may classify the verbal elements of all phonetic language in the following manner:

Interjections, that is, primary phonetic symphenomena of the inner state of man. We have seen that Laura possesses them as a matter of course. If she has not the distinctly articulate interjections of developed languages, it is because her state excludes her from a share in our stock of articulate sounds

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* The tenth report was published in 1842. Laura speaks now far more correctly. The damsel has, even by this time, acquired a great relish for what we would call high-sounding words. *C'est tout comme chez nous!*

and words. For, articulation is the combined result of a reflecting mind; of an acute ear, which hears the sounds of others and our own; of vocal organs, trained for many years; of the effect of continued traditional utterance; and of a skill, gradually acquired, unconsciously to analyze sounds which we perceive.

As the second class may be mentioned positive imitations, or copies of sound —the onomatopy of the grammarians. Man resorts to it at the earliest periods, partly led to it by the inherent imitative principle; partly because sound, wherever it is produced at all, is the most distinctive characteristic, and becomes the readiest sign for the being that utters it, inasmuch as the ear perceives a sound, and nothing more; while the eye perceives at once an object in all its visual relations, as an image which must be analyzed in order to be described. The eye perceives totalities, the ear single characteristics. It is incomparably easier to designate a sheep or a cataract, by imitating the bleating of the one or the rumbling noise of the other, than to describe them by words already existing, or by drawing outlines of these objects. All languages, therefore, are full of such words as Sibilare, Mutter, Whiz, Splash, Boan, Bronte, Claquer, Knarren, Lachen.

Men, naturally, take refuge in the onomatopy, when they must commune with one another without mutually knowing their languages. There is a very interesting paper by the late Mr. Gallatin in the second volume of the Transactions of the New York Ethnological Society, on the "Jargon," or Trade Language of Oregon. The reader will find there a long list of onomatopies, such as are frequently formed in our nurseries, where the dog is called *bow-wow*, or the cow *moo-moo*. Thus the words *tingting*, *he-he*, *mash*, *tumtum*, *poo*, signify in that Oregon Jargon, respectively, bell, to laugh, crushed or broken, the heart, to shoot.

Laura not hearing any tones, cannot, of course, originate onomatopies.

Two other classes of words are at once formed from the two preceding ones. Interjections themselves are used at an early period as words, (as I have heard children say, "This is fie," for this is naughty;) but what is more important, interjections soon form the roots of other words. Thus the feeling of wonder seeks vent from every human breast in the symphenomenal sound of *o*, or one between *o* and *a*, (the latter as in *father*.) The ideas of admiration and wonder again, and more of height, tallness, power, are closely connected in the human intellect; so that we find in original languages words designating height, elevation, derived from this interjection, as the German *Hoch*, for high, which is nothing but the interjection *o*, wrapt as it were in strong aspirates. Every where men cast shame upon others by an interjection sounding *Aih*; and αἰδῶς means, in Greek, actions of which we ought to be ashamed; and *Aetschen*, in German, means to call *aih* at a person, or strongly to deride him. Disgust, mingled with contempt, is expressed by all men by a symphenomenon, which consists of a sharp exhalation of the sound *f*, which is the combined effect of the lower lip being somewhat protruded, while the upper one is contemptuously drawn up, and the breath is strongly uttered—all, the effects of the prevailing

feeling of disgust. This *f* sound leads to the universal interjection of *fie*, *pfui*, *fi*, or φεῦ—the vowel, the most liquid element of speech, changing in the different languages, as it would with different individuals, before usage has settled one vowel as the adopted one. This fie, or fi (in French,) is the root of the word Fien, to hate, in Low-German and ancient Franconian, and of Fian in Anglo-Saxon; whence again the noun Fiend, in English, is derived, as likewise Fijend in Low-German, Feind in German, Fient in Swedish, Fiant in ancient Franconian, and Vejant in Dutch, for hateful enemy, a malignant being. The Greek φεῦ indicates more an interjection of pain; but that which is the utterance of pain becomes that of dislike if exclaimed *at* an object. The two ideas are near akin. We have, therefore, φεύζω to indulge in sounds of woe, or to call φεύ; and is not φεύγω, to flee, (from that which makes us exclaim φεύ, that is, from that which is painful, disagreeable to us,) derived from the same root? *Ototoi* was the Greek articulated exclamation of grief, and ὀτοτύζω is to moan, to give vent to grief. The Greek language requires the addition of a termination which indicates the verb. The same would be the case in German. In English this necessity does not exist; and a leading article of a distinguished London paper* lately said of the Secretary for foreign affairs, "He will pooh-pooh such particularity;" that is to say, he will dismiss such particulars disdainfully as trifles, while uttering the interjection pooh! pooh!

A member of my own family showed, in early infancy, a peculiar tendency to form new words, partly from sounds which the child caught, as *to woh* for *to stop*, from the interjection *woh!* used by wagoners when they wish to stop their horses; partly from symphenomenal emissions of sounds. Thus when the boy was a little above a year old he had made and established in the nursery the word *Nim* for every thing fit to eat. I had watched the growth of this word. First, he expressed his satisfaction at seeing his meal, when hungry, by the natural humming sound, which all of us are apt to produce when approving or pleased with things of a common character, and which we might express thus, *hm*. Gradually, as his organs of speech became more skilful, and repetition made the sound more familiar and clearer, it changed into the more articulate *um* and *im*. Finally an *N* was placed before it, *nim* being much easier to pronounce than *im*, when the mouth has been closed. But soon the growing mind began to generalize, and *nim* came to signify every thing edible; so that the boy would add the words *good* or *bad*, which he had learned in the mean time. He now would say *good nim*, *bad nim*, his nurse adopting the word with him. On one occasion he said, *Fie nim*, for *bad*, *repulsive to eat*. There is no doubt but that a verb *to nim*, for to eat, would have developed itself, had not the ripening mind adopted the vernacular language, which was offered to it ready made. We have, then, here the origin and history of a word which commenced in a symphenomenal sound, and gradually became articulate in sound and general in its meaning, as the organs of speech, as well as the mind of the utterer,

* London Spectator of the 27th July, 1850.

became more perfect. And is not the history of this word a representative of many thousands in every language, now settled and acknowledged as a legitimate tongue?*

We meet with articulated sounds which are yet in a middle state between a pure interjection and a distinct word, as the German sweet expression, Eiapopeia, pronounced i-a-po-pi-a—the endearing and lulling sound with which the German mother sings her babe to sleep. *Ei* and Eia (the *ei* pronounced *i*, as in fire) is the German symphenomenal sound of endearment which accompanies the patting of the rosy cheek of a child, and the maternal desire to bring down slumber upon the infant has drawn out this primative sound into *eiapopeia*. Now, many cradle songs, as the Germans call the rhymes sung by the cradle side, begin with this—what must it be called, interjection or word? It is neither. At times, indeed, a "cradle song" is called an Eiapopeia. In this case it is a perfect noun. And is not the English lullaby much the same? The syllable *by* is the same sound *by*, which, in the gentle nursery idiom, means sleep, when the mother sings *by*, *by*, and *lull* is depictive of the act it designates. The French, when they desire to imitate the sound of the drum, say *rattaplan*, for which we say *rub-a-dub*, and the Germans have *brumberum*. They are imitative sounds, articulated, yet in an undefined state, so far as grammatical classification is concerned, while *drum* has become a distinct noun.† It may be observed,

* This child made other remarkable words. Every one who has studied the languages of our Indians, and some other tribes, as, for instance, that of the natives of Burmah, is struck with their words which express a number of ideas, indicated in our analytical tongues by a series of words. William von Humboldt called this process *agglutination;* but as this term would indicate a joining of what has been separate before, which is by no means always the case, I preferred the term *holophrastic* words, in a paper on this subject which I published in the March number, of 1837, of the Southern Literary Messenger. It is for the same reason that I preferred the term to that of polysynthetic words, which Mr. Du Ponceau had proposed.

The child in question had become most impressed with the word *Good*, when in connection with the noun *Boy*; that is to say, when he himself had been called a good boy, which he pronounced *Goobboy*. It formed one word for him, so much so that his infantine mind could not separate the two parts, in this case actually agglutinated, to use the term of William von Humboldt. When the child, therefore, one day desired to express the idea Good Cow, he said *Goobboy Cow*. He found the same difficulty of expressing *good cow*, which many of our missionaries have to contend with, when they desire to express Christian ideas by words which carry along with them numerous associated ideas of different things and relations. Father Sangermano, if I recollect aright, says in his work on Burmah, published by the Oriental Translation Fund, that he could not simply translate the passage in which it is related that a woman washed the feet of the Saviour; for, although there are ever so many words for washing in the Burmese language, yet each word carries along with it many conditions and relations of washing inapplicable in this case.

Similar, so far as the connexion of ideas is concerned, was the case of a little girl who, in my hearing, said to a man, *Doctor naughty girl*, because he had teased her. Her mind had received the idea of *bad* chiefly in conjunction with girl, that is, herself, when rebuked for some fault or other. "Bad girl" was, in her mind, one term, or a holophrastic word.

† Thus I wrote; but one of the greatest orators of the age, or any age, has since said in the Senate, (Mr. Webster, on July 17, 1850,) "They have been beaten incessantly, every month, and every day, and every hour, by the din, and roll, and rub-a-dub of the abolition presses." He uses rub-a-

in passing, that this latter instance shows, in a striking manner, how different tribes view or perceive the same phonetic phenomenon (hear the sound of the drum) differently, according to the different genius of the nation; yet all may be equally correct in their own way.

Out of the second class, or purely imitative words, arises another very large one. It consists of those words which, so far as their sound goes, are derived from onomatopies, but have come to mean something which is only occasionally accompanied by the originally imitated sound, or is not so any longer at all. Such, for instance, is the English word grumbling, which originally indicated the physical sound of grumbling, but now frequently means the mental act of petty dissatisfaction. A man may grumble in a clear voice. To the same class belong the French *gronder*, the German *krazen*, (to scratch, and pronounced krat-sen,) the Greek χράω, from which is derived γραφειν, to grave, to engrave, and, ultimately to write, as if we used *scratching* for writing; and, by a farther extension of the meaning, for composing, corresponding, and other significations, which the expansive word *writing* has received in the course of time. The German word *Schmecken*, (of the same root with the English to smack,) which now means to taste, both as an active and a neuter verb, is here in point. It is derived from the sound which is produced by a person eagerly tasting some substance—an action expressed by the French *claquer*, and the English smacking; the latter of which also signifies to savour of something. For, the active and the passive, the cause and the effect, the state of a thing and the action resulting from it, the perceiving and the causing of the perception, are ideas constantly passing over into one another in the human mind, and produce corresponding results in language.* But the German word extends its meaning still farther, for *Geschmack* is the term for taste, in all its meanings, as if the English *smacking* were used for the sense of taste and the cultivated æsthetical perception and judgment, or as if the French used *claquement* for their word *gout*, in the fine arts, though the very words *gout* and *gouter* are derived from the Latin *gustus*, which, with its guttural sound, belongs likewise to the present class. It was, originally, an imitation of the sound produced by the act of swallowing, or the reversed sound of *gulping* (also a word to be mentioned here.) The German *plump*, now meaning clumsy, was suggested by the sound which the fall of a heavy and unelastic body produces. The Greek pneuma, meaning mind, but originally breath, is derived from the sound of breathing forth. The Chinese word gong means the instrument which produces the sound

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dub as a noun, as *din* had been used by others before him, and as *eiapopeia* has been used by the Germans as a substantive. What are the Latin clangor, clamor, the German Klang, but words of this sort? We might imagine a Hudibrastic writer using the expression, "*They rub-a-dubbed it all about.*" No dictionary, however, in my possession, has Rub-a-dub; by and by the lexicographer will admit this, as yet, half-wild word.

* One of the most striking instances is our "*I am told*," for "It has been told to me;" as if the Latin *narror* (they say of me) were used for "they tell me;" or as if the English "*I am reported*" did not mean "It is reported of me," but "It has been reported to me."

gong. The English *sly* means cunning, but is derived from the root of the word sliding, which, like the German *schlupfen*, is an imitation of the sound made by nimble bodies moving quickly on smooth surfaces. To clip, now meaning to cut off the tender ends of bodies, is derived from the noise made by the act of clipping. So is the English word to nip derived from a sound. In German *nippen* means to sip; both are, originally, of phonetic imitation.

The following is one of the most striking and interesting instances of words belonging to this class:

The Latin *vivere* and the Greek βιεῖν are of the same root with the Gothic *quivan*, which, etymologically, is the same with our *weave*, that is, to move to and fro, as the German *weben* actually means to weave, and to move as a living body or entity—a sense which *move* has in the great passage of the Bible: In Him we live and move and have our being. The German is, "*In ihm leben und weben wir*." Of the Gothic *quivan* was formed our *quick*, which means both living and rapid, for the ideas of life and motion are closely united, so much so that we cannot imagine unalterable sameness without the idea of death, or lifelessness; while *quivering* has the meaning of trembling motion. But this original root is probably the same which we find in *live*, the German *Leben*; and these words originally mean to utter a loud noise, to cry. They are etymologically the same with the low-German *Leuen*, the English to low. Hence the German *Leu* and *Lowe*, and the Latin *Leo*, for lion, that is, the *roarer*. *To low* is a clear imitation of the sound, while the idea of tone, of utterance, is as closely connected with that of life as the idea of motion. Indeed, wherever life surrounds us we see motion and hear sounds—be it utterance or noise caused by motion. It is not maintained that men reflected on this close connexion, but a noise, a cry, an utterance naturally suggested the idea of life, and the word or verbal sound indicating the one was necessarily taken for the other; as an anxious father, doubting the life of a new-born infant, will exultingly exclaim, *It cries!* meaning it lives. The Hebrew *Lēv*, for heart, because it pulsates, moves, or *lives*, probably descends from the same root. It is not useless to remark here that, in common German parlance, the word *Leben* (life) has to this day the meaning of uproar or noise. Many a German schoolmaster says, admonishingly, to his pupils: "Boys, do not make so much *life*," when he suddenly breaks in upon them in the midst of a youthful tumult. We have, then, here again a word which is originally an imitation or a sound evoked by sound, but which gradually comes to designate various, very different and vast ideas.

I have given a sufficient number of instances to illustrate this class of words. Whoever will direct his attention to it will no doubt be as much surprised as the writer has been, at the immense number of words reducible to this class.

Laura, of course, could not attain to these classes of designating sounds, because she could not even attain to those whence they are derived.

Under the fifth class of words may be comprehended those which have never designated a sound, but whose sound, nevertheless, stands in a direct psychological connexion with the object to be designated, or the idea to be expressed—

as much so as interjections do. There is, indeed, a close affinity between the two. The words of this class are of a symphenomenal origin, and, for this reason, are easily understood when first uttered; almost as much so as the mere cry of pain or joy is. These peculiar words always form a most enlivening and spirited part of human speech; I mean such as the English ***Flash***. Every one feels at once that there is an affinity between the sound *flash* and the impression which sudden, vivid, and passing light produces upon our visual organ. The high sound, we might almost say the *brightness* of the sound *a*, as it is pronounced in this word; the impression which the sound *sh*, at the end of the word, produces in this case, reminding us of *splash* and *dash*; the quickness expressed by the sound of *fl*, associated, as it is in our minds, with the words *fleet*, *flicker*, *flight*—all these contribute to make the word ***Flash*** one which accurately paints with sounds (I cannot otherwise express it) the flashing light. How close the affinity of impressions is, made by sound and light, and, indeed, by many other causes, appears clearly from the fact that the same root has often produced in one language a word designating a phenomenon of sound, and in a cognate language a term for a phenomenon perceived by the eye. We have in English to Titter, and in German *Zittern*, both derived from the same root. Every etymologist well knows that *T*, *Z*, and *S* frequently pass over into one another. But the German word *Zittern* means to tremble, while the English Tittering means to laugh in an under-tone, with a tremulous voice. There is a close affinity between the two phenomena, which is indicated by the fact that the expression just used of *tremulous* voice is intelligible and legitimate.*

The Greek *Lampas*, the German *Bliz*, the Latin *Clarus*, seem to me to belong to this class; so the English *Whirl*, if it does not belong to those words which originally have actually indicated a sound, as the German *Schwirren*, which is of the same root, but means a sound similar to the word itself, seems almost to prove. Most original words designating phenomena of light belong to this class.

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* This is not a confusion of ideas, as little as there was confusion in the mind of the blind man, who was asked how he imagined, from all he had heard, red color, when he answered: "Like a trumpet sound for the eye;" or as there is confusion in the poet's mind when he boldly transposes words which belong to one sensuous sphere to another; Dante speaks of a *silent* sun—that is, of a sun not shining. In this poetic temerity lies often Shakespeare's greatest beauty and Milton's highest sublimity. If this transposition were not intelligible, human speech would hardly be possible; and if the mind did not perceive things and evolve thoughts in its oneness, they would not be intelligible. Expressions such as space of time, strong sound, cold or warm coloring, sweet voice, waving music, crying red, a clear tone, a dull sound, high-minded, sharp taste, a flat fellow, an itching desire, and a thousand others, would convey no ideas. The whole meaning of the metaphor and the trope must be explained upon the same ground. There is but one sensorium where all sensations center, no matter which sense may have been the channel of perception, and whence all the urgency to breathe out the word proceeds. A most curious instance of this transposition from one sensuous sphere to another was once afforded me by a little peasant boy in Thuringia. He said to me: "Dear sir, buy this nosegay; the violets taste very loud"—meaning they smell very strong. Yet this double transposition is perfectly intelligible, nor was it for the boy a transposition. The expression proceeded entire from *one* indivisible mind, and radiated, as it were, into different spheres of perceptible objects of the world without.

Properly speaking, the origin of these words must be referred to the first class—the primitive interjections, and so far we find them in the case of Laura; but we cannot expect to hear them from her lips as actual words, purposely and logically uttered, in order to convey distinct ideas, for the reasons of which we have already spoken.

There ought to be mentioned, in connexion with this class, those curious alliterations which have acquired a very distinct meaning, and are, consequently, universally understood, but are derived from no ordinary words; or, if they are so, use is made of the original words for their exclusively phonetic impression upon the ear, rather than for the meaning conveyed by them; or, lastly, the alliteration consists of syllables without any separate meaning of their own, added to existing words. Some of these alliterations are purely imitative, as the French *Din-don*, *ping-pang*, the German klip-klap. Others have a symphenomenal connexion with the idea they express; in English, for instance, fiddle-faddle, rip-rap, slip-slop, hodge-podge, namby-pamby, tit for tat, higgledy-piggledy, and zig-zag.* In others, as indicated before, a symphenomenal sound is added, to a word, as chit-chat, see-saw, tit-bit, clap-trap, the German Misch-masch, schnick-schnack, holter-polter, the French pele-mele. Others, again, seem to remind us of an original word, or do really so, but have relapsed into a symphenomenal state, *painting*, as I said before, with sounds the idea within us, as the English nilly-willy (in which the Latin *nolens volens*, and the English *will*, have curiously relapsed into a primitive symphenomenal state,) flibberdy-gibberdy, the American teeter-tawter (the English tiller-toller,) hurly-burly, and a great many others. The American vulgar noun *slangwangher*, for a boisterous and arrogant fellow talking loudly and rudely in private or public, belongs to this class. †

* When the wife of Sir Thomas More exhorted him, in prison, to yield to Henry VIII, she replied to one of his noblest observations, "Tilly-valle, tilly-valle;" which Sir James Mackintosh, in his Life of that great man, calls "an exclamation of contempt, of which the origin or meaning cannot now be ascertained." The meaning is very plain; it is obviously the same with "fiddle-faddle," which means, "You talk stuff to no purpose; good enough on other occasions, but worth nothing on this." And as to the origin, it is purely symphenomenal; the sounds *paint* the impatient censure and low esteem in which the remark to which they apply was held by the worldly wife. The sounds *i* and *a* are taken, as generally prevailing in expressions of this, or a similar sort, in the English language. A noble member of the House of Commons, in the late debates on the admission of Mr. Rothschild, protested "against any farther *shilly-shallying*." He made a verb of the exclamation *shilly-shally*, which is quite as intelligible as Lady Moore's *tilly-valle, tilly-valle.*

† There are in all modern languages, but especially, it seems, in the Teutonic tongues, certain names and adjectives used merely for the purpose of emphasis. Originally they signify something strong, fearful, awful; and this general sense, without any reference to the particular object they designate, remains when they are used in the connexion here spoken of. The vulgar Germans thus use the word *murder*, merely to express the idea of *very much* in the strongest manner. They would say, for instance, "I like him murder well;" "I am murder busy." Thus we may hear in English, "He is a thundering fine fellow." The words devil, devilish, and d——d, are used in this emphasizing manner. Several times I have even heard the latter word used in the superlative, and as a noun, namely, in this connexion: "You may do your d——dest, you will not succeed;" or, "He has done his d——dest, but it's all useless;" that is, his very utmost. Now, in these cases, the *weight* of the

In the sixth class may be ranged those regular words which are formed by the addition of a syllable of symphenomenal character—syllables, as have been mentioned in the preceding paragraph, to some existing word. The German has the word ***Bitten***, (to pray, i. e. of man, not of God;) of this he forms the frequentative ***Betteln***, to beg, that is repeatedly praying, in a small way, for a small gift. It seems to be obvious that the affix *ln* has the same symphenomenal affinity to the ideas of diminutiveness and repetition that ***flash*** has to sudden, bright, and passing light. The Italian affix *accio*, or *one*, the one expressing badness to contemptibleness, the other indicating amplification, seem to me of the same sort. Whoever has heard an Italian using them, with his expressive enunciation, will at once understand their peculiar import. The Greek desiderative syllable ειώ is probably of a symphenomenal nature; so are all diminutives which are not originally independent, but now faded nouns. The intensive *S* of the Teutonic languages ought to be mentioned in this place.

What has been observed of Laura with reference to the fifth class applies likewise to this set of words.

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words for which alone they are used is derived from their meaning; indeed, still more of them are unconsciously used because their sounds correspond to their weighty meaning. The German word for murder, for instance, is mord, (pronounced *mort*, with a strongly shaking *r*,) and the vulgar would not use it as a mere emphatic, did it not express the awful idea of murder by a heavy and strong sound. But it is found that the vulgar, especially in Ireland and our western regions, form entirely new words in a similar sense. The final syllable *acious*, in the English language, has a peculiarly emphatic sound. The vulgar, therefore, frequently attach it to adjectives, merely to add a heavy weight to the word. I have thus heard the words *gloriacious*, *curiacious*, for "very glorious" and "very curious." The many Irish tales published in England contain numerous words of this sort. In one of them I lately found this expression: "You need not tossicate thus your head," for, you need not thus violently toss your head. A remarkable slang word of this sort is the adjective bodyacious, vulgarly used in the South, and meaning total, root and branch; for instance: "The hogs have broke into my garden, and destroyed it bodyaciously." Here the termination *acious* is made use of merely for its phonetic value, or weight; while the word body probably suggested the idea of totally—the entire body. The slang of the vulgar is interesting to the philosopher; because, in the uneducated, if they are of a sprightly mind, the same native, formative powers are at work, which are observed in the earliest tribes and in children. I think it is Lessing who, for a similar reason, says, that intoxicated people sometimes invent most characteric words. The state of intoxication reduces the individual to a state of untrammelled savageness, in which the impulsive power of the mind, as far as it goes in that state of mental reduction, resumes a proportionate degree of original, formative vigor, unconcerned about that which is already existing and acknowledged.

I cannot forbear relating here a droll anecdote connected with the German word for murder in the sense which has been indicated above. Soon after the war against Napoleon, in the year 1815, the Prussian Government thought it proper to institute prosecutions against many persons who had fought for the country, on account of suspected liberalism. The writer of these pages, then a mere lad, was among them, and arrested on suspicion of having dabbled in liberal politics. All his papers were taken from him, and submitted to the searching eyes of the police. Among these papers was his journal, which contained, under the head of one day, this passage—expressed, it is now owned, in somewhat too familiar a style even for soliloquy—"All day murder lazy." This grave line was marked with the serious red pencil, and the writer was repeatedly teazed with the question whether he had not meant that he had been negligent in imagining (and compassing) the death of persons who, according to his opinion, stood in the way of establishing a constitutional government in Prussia—lazy in murderous thoughts! The inquiring judge considered himself, no doubt, very sagacious.

In the seventh class I would comprehend those words which, in the advanced state of a language, express a quality which is the cause of an effect that is accompanied by the sound which has suggested the word—a natural transposition or extension of the meaning. The following may serve as an example:

Mum is the English interjection for silence. How has it arisen? When we address erroneously a deaf-mute as a person able to hear and speak, and he desires to make us understand that he cannot speak, he compresses his lips and breathes strongly against the palate (so decidedly does thought or feeling animate the organs of respiration, and so phonetic or sound-seeking is the nature of man.) This produces a humming sound—*um*, or *mum*. The same is observed if children play the mute, or if the actor in the vaudeville wishes to impress others that he is mute, or ought to be silent. *Um* is the root of the word Dumb; but in German *Dumm* now means stupid, that is, the cause of silence; as we, also, say for a dull person, "He has little to say for himself." In ancient German poetry we find the expression, *Die Alten und die Dummen;* literally, the old ones and the stupid, and really meaning the old ones and the young, because the young ought to be silent, or have nothing important to say. This agrees with the views of all early nations, who, on the one hand, always connect the idea of old with wisdom and authority, and on the other, that of youth with the want of these qualities. We have changed all this, and have "young men's parties," "young England," "young France." But such was the view of those who made of the terms for old man, father, &c., the names of their highest offices—as γερων, senator, papa, abbot.

These words, as a matter of course, cannot be expected to belong to Laura.

As the eighth class of words, we may mention those which are derived from sounds which stand in an incidental, though natural, connexion with the objects which they designate, and which are not therefore of a strictly symphenomenal nature. The simplest of all vowel sounds is *A*, (pronounced as in Italian,) or *Ha;* for it is the mere breathing forth from a mouth opened before the breathing began. If the mouth is closed again before the breathing wholly ceases, the sound *Am* is heard; if the breathing begins before the lips are parted, we have the sound *Ma;* if the breathing precedes and succeeds the opening of the mouth, we have *Mam*. What wonder, then, that children articulate, at the earliest period, the sound *Am*, *Ma*? What wonder that this sound is uttered so soon as mere animal crying gives way to articulation, and that the only want felt by the infant, that of nourishment, urges it, according to the general organization of all human beings, to breathe forth its desire in the sound *Ma*? What wonder if this first articulate sound comes to be attached to the being who furnishes the nourishment, or the breast which yields it? Has not even the bleating of the lamb the sound of *ma* or *maih* in it? Whenever this sound of the lamb is imitated, it is done by the prolonged and tremulous sound of *maih*. What wonder, lastly, if the sound *ma* or *am*, once having come to signify the being that gave birth, is surrounded, by her affectionate care, with all the dearest associations of love and holy disregard of self?

In almost all languages the word for the female breast, the mother or the nurse, is derived from this sound. The Latin *mamma* and *mater*, the Greek μάμμα, the modern mama, the Hebrew *Emm*, the Persian and Hindoo *Ma* for breast, the Greek ματηρ, our mother, the German *Mutter* and *Amme*, (for nurse,) the Gaelic *mam*, the Sweedish *mamma*, the Albanian *mam*, the Wallachian *mama*, and innumerable others, are all in point. We meet with it again in the Polynesian languages, as the philological part of Capt. Wilkes' Exploring Expedition shows.

I make no doubt but that Laura, too, has breathed forth this elementary and sacred sound, in her earliest infancy, but it could not ripen into a definite word.

All other words are, probably, formed by composition, contraction, expansion, repeated transformation, and certain changes which gradually come to designate a general or peculiar relationship subsisting between certain ideas, or between the forms of words themselves in a purely grammatical point of view, the whole being essentially affected by the peculiar formative spirit with which a tribe shapes its words, whether, for instance, it is analytical, whether monosyllabic, as with the Chinese, or holophrastic, as with the American Indians. While these changes are going on with the formed words, their meaning alters according to the endless association of ideas, real or imagined affinities, the gradual expansion of the mind, the constant generalization and abstraction, or a retrogressive degeneracy, and many other causes, mental and physical. It will have been observed that I have spoken only of the origin of words and of their phonetic formation. The meaning which they acquire constitutes a different subject, which demands attention to all the laws of psychology, of the gradual progress of civilization, to the laws of intellectual and philological degeneracy, (for this has its laws like all disintegration or corruption,) to the changes of history, and, in short, to all the altering conditions and relations which take place within, under, and around Man, individually and collectively, by tribes and nations, by concentration and tribal separation, by mixture, fusion, and by emigration—in politics, religion, the arts, and every advancement and debasement.*

* If, on the one hand, it is true that etymological inquiries may lead to very fanciful conclusions, if they are not conducted with the utmost caution, it is no less true, on the other hand, that etymological connexions may actually exist, which would appear as most extravagant could they not be proved; and no word, in its present state, can fairly be assumed to prove that its origin is not owing to one of the enumerated causes. Who would believe that the Hindostanee words, used by the native soldiers in the British dominions of the East, *Gourandile*, *Ordulram*, and *Tandellis*, are the corruptions of the words *grenadier*, *order arms*, and *stand at ease?* Yet such is the case. Many words change, in one transformation, their vowels, and in another their consonants, so that nothing of the original remains. The following is an instance. The Sard word for voice is Boghe, derived from the Latin, vox, vocis, of which the Italian word *voce* is formed. The *c* constantly changes into *g*, (having first a slightly guttural sound,) and *v* and *b* are equally related to each other, as every Spanish scholar well knows, so that at last the word *boghe* is formed. But in some parts of Sardinia the people pronounce this word very much like *baghe;* so that we have *baghe* from *vox.* Who but the sifting scholar would believe that the words *voice* and *baghe* are derived from the same original word *vox*, which, again, may be derived from an original sound, consisting merely in a strong breathing forth of *Ah*, or *Oh;* for *v* and *c* are but hardened aspirates, or solidified breathings. The history of many a word—both of its form and its meaning—is as significant and instructive as that of many institutions.

In all inquiries into the origin of words and languages, we must remember this psychological fact of primary importance, that, in consequence of the force of the assimilation of ideas, the inquirer who sees a thing or institution in a defined and ordered state before him, is apt involuntarily to suppose a correspondingly definite and distinct origin from which it has sprung. Accordingly he seeks for this peculiar sort of origin, and is generally led into grave errors. When attention was first directed to the origin of governments, they existed already in a well defined state, and forthwith an origin corresponding in distinctness was sought for and imagined. People dreamed of governments voted into existence as laws are now made. Agriculture, when first it became a subject of reflection, presented itself as a complicated system, far too wise to be supposed to have been invented by man—and its *invention* was silently assumed. It was, therefore, ascribed to the gods, by the Chinese as well as by the Greeks. Even the *invention* of bread has been sought for in the inspiration of some benign deity. The origin of languages has naturally been exposed to the same error, and more so, perhaps, than any other subject.

Although we can trace in the case of Laura words appertaining to only a few of the enumerated classes, her vocal sounds are nevertheless interesting even in this respect. I shall proceed, then, to give as accurate an account of them as I am able to do, founded upon personal observation, whenever the nature of the case allowed it. Where this was impossible, my remarks are founded upon information obtained from persons who have been in daily intercourse with her for a long time.

It has been stated that most of the sounds which are the symphenomena of Laura's emotions have been studiously repressed, because, being impulsive, they are more or less vehement. But sounds vehemently produced by organs over which the regulative power of vocal intercourse has no influence, are necessarily disagreeable or repulsive to others.* Laura, however, was educated

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* The admirable organs of speech, and the definiteness of thought, which is accompanied by an urgency to *name* the thing or utter the idea, lead men to articulate sounds; so much so, that articulation becomes natural to man, and will take place even where no definite thought exists and requires it. I knew a gentleman, bearing the name of one of our most distinguished men—both are now departed—who was in the habit of beginning every address of his, and every paragraph of speech, if I may use this expression, with the distinct word "*Titnoss.*" For instance, "Titnoss, how do you do, Madam?" If he was somewhat embarrassed he used to begin every sentence with "Titnoss." Upon inquiry, I found that originally he stammered a great deal; indeed, he was always liable to have his speech impeded by this unwelcome disturber. Now, *titnoss* is nothing more than the sound which the perturbed organs produced in a stammering person, before the tongue assumes its proper enunciating function, viz., ti-ti-ti-ti-ti-s-s-s, gradually subjected, however, to the articulating process, until a regular *word* (titnoss) was formed. This word had no meaning, indeed; at least no more meaning than the *ach*, *ja*, with which the Berlin people and Saxons begin almost every first sentence, or than the δε of Homer; but if the original unarticulated sound had arisen from any specific emotion, e. g., from fear, love, hatred, pleasure, or kindness, and if the utterer had been a barbarian, living with kindred, yet speechless, barbarians, it is clear that this sound—and, later, the articulated sound, *titnoss*—would have become a *phonetic sign*, a *word* in our sense of the term, for that specific emotion,

for her own sake, and not as an experiment for the philosopher. Sounds which she produces for persons—and she has a sound for every individual in whom she takes a peculiar interest—are not subject to the same vehemence; indeed, they are not at all disagreeable. The question whether Laura has distinct sounds for those persons only whom she loves, but none for those she dislikes, is simply answered by the fact that never a being has been more exclusively surrounded by attentive solicitude than Laura.

How these sounds for persons, or names, originate is very difficult to say. I was unable to discover any agreement between the sound—for instance, its strength or softness—and the character which Laura may ascribe to the individual, or with the peculiar influence which a person may have exercised over her.* This apparent want of agreement cannot be wholly ascribed to a want on her part of an appreciation of the difference of character. Laura knows the character of those who surround her very well indeed. She quickly perceives whether a friend speaks to her with accustomed kindness, indifferently, or perhaps impatiently. For, as we readily perceive the temper of a person by his gentle intonation or hurried utterance, so is Laura perfectly able to feel any difference in the manner of imprinting words in her *listening* hand. Once she said in my presence to a friend of hers, "You are very sleepy; why don't you go to bed?" and when asked how she knew it, she replied: "You speak so sleepy." The fact was, that the person really was tired, and printed her converse slowly in Laura's hand, as our utterance becomes symphenomenally heavy when we feel drowsy. One day Laura expressed a desire to visit me; and when asked whether she liked to see me, she answered: "Yes, he speaks so funny"—imitating my slow and often incorrect spelling. I was then learning her finger alphabet, and used to spell as slowly and painfully as the urchin performs his first lessons in the primer. Now it is obvious that if Laura perceives single peculiarities, she likewise conceives the aggregate, especially as she is gifted with very keen perceptional powers. We have, indeed, her own sayings, which prove how well she appreciates those around her. But the reasons why there seems to be no natural agreement between her sounds and the persons designated, may be twofold. Laura has no ears to guide the modulations of her own voice, or, in fact, to evoke the proper sounds; and, which is perhaps the most important, Laura perceives that which to us is sound, as a common vibra-

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and titnoss would stand in the dictionary of that tribe as the *noun*, or *verb*, as the case might have been, for fear or fearing, love or loving, &c. There are many perfectly articulate sounds used in our language, which, nevertheless, have neither a destinct word-meaning, nor are interjections; for instance, the sounds which are added to some stanzas in singing, as la-le-ra-la, foll-de-doll, or Sterne's lilli-bullero.

In the above case a human being was forced by his own organization to form an articulate bisyllable of a mere sound of embarrassment; while a Newfoundland dog, with a most definite idea, cannot rise to articulation. What an elemental difference!

* I must refer the reader to the letter of Miss Wight, which I received when these sheets were passing through the press, and which will be found at the end. It will be seen that Laura actually does connect some of these sounds at least with the character of the persons whom they designate.

tion of her organs only. It must be observed, also, that the loudest letters, for instance a loud *R*, (pronounced as in Italian,) are not necessarily *felt* by the organs of speech as strongly as some guttural tones, which are far from resembling them in strength. Possibly, then, there may yet be the agreement of which we have spoken, according to Laura's own perceptions and impulses. One of her teachers told me that Laura once omitted to produce the accustomed sound indicating the person who related the incident, for a whole week; after which she uttered an entirely different name-sound, and said: "This is your name," which name the teacher retained at the time the account was given to me. It is clear that at the present advanced stage of Laura's education many causes which come into play when we make or give names must be active with her; but how her mind came first to settle upon the precise sounds which she has given to certain individuals may never be discovered.

I have given my view how the fact is to be accounted for, that she has sounds for persons, and none or very few for things and actions. I think one more reason may be adduced, proper to be stated at this stage of our remarks. Every word whatever, except nouns proper, is the representative of an abstract idea, because it is generic, and the idea of a genus is an abstraction. This process of abstraction, accompanied by sounds, which must at all events have been in her very limited and laborious, was wholly stopped by giving her a full and developed, a ready-made language. It operated upon her native development of language as the superinduction of the Roman law foreclosed the further development of the German common law; or as the introduction of a fully developed foreign architecture has cut short the native architecture of some countries, which happened to be yet in the process of formation; or as, indeed, the influx of the Latin language often operated in the middle ages.

An individual, however, is something concrete, and his noun proper, of whatever sound this may consist, means the concrete individual, and nothing else. The names of persons which were given to Laura were no sounds or representations of sounds, but spelled digital marks. There was, therefore, no forestalling possible by a ready-made language, and all the original formative impulses retained their primitive vigor. A name was given her, but she could freely invent another of her own kind, parallel with the first; or perhaps she had already given such a one.

Laura has near sixty sounds for persons.* When her teacher asked her, at my suggestion, how many sounds she recollected, she produced at once twenty-seven. Three of her teachers, Dr. Howe included, stated to me that she had certainly from fifty to sixty.

It may possibly excite surprise that I do not speak with greater certainty. But it ought to be observed that these inquiries must be carried on with some degree of caution, so as not to cultivate in Laura a feeling of vanity, from which this little

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* Here I must again refer to the letter of Miss Wight, at the end, from which it appears that she has forgotten many, and now uses but few.

personage is by no means entirely free. She is already aware that she has attracted much observation and inquiry; and, being an object of uninterrupted solicitude, she might easily become selfish.

Her oral sounds indicate persons only. She never attempts to designate individuals by the clapping of her hands, or by stamping her feet. The reason seems clear. These sounds would be intentional in their origin; and how could she know that by bringing her hands violently together she would produce a sign? The uttered sounds were spontaneous in their origin; and finding that somehow or other they were perceived by others, they became signs or names.

Sometimes she produces these phonetic names involuntarily, as I have mentioned an instance when she affectionately thought of a friend. So, whenever she meets unexpectedly an acquaintance, I found that she repeatedly uttered the sound for that person before she began to speak. It was the utterance of pleasurable recognition. When she perceives, by the jar produced by the peculiar step of a person entering the room, who it is, she utters the sound for that person. At other times, when she is in search of somebody, she will enter a room uttering the sound belonging to the person; and receiving no answering touch, will pass on. In this case, the sound has become a complete word: that is, a sound to which a definite idea is attached, intentionally uttered to designate that idea.

All the sounds of Laura now designating persons are monosyllabic. Not one of the names thus bestowed by her consists of a composition of two syllables, each of which separately might designate another person. Nor does she use the same syllable differently uttered, in the Chinese manner, for different persons. But this monosyllabic name is repeated several times; for instance, Foo—Foo—Foo; or, Too—too—too. She has no name Foo-Too. All impulsive utterance is probably at first monosyllabic, and the aid of the ear, as well as phonetic intercourse, may be necessary to connect different syllables in order to designate one idea. In the constant repetition, Laura resembles children and uncivilized tribes. Most of our nursery names for animals consist of repetitions of the same syllable, while the languages of savages abound in reduplications of the same sound. I observed the same when the different armies entered France, and the soldiers of different nations came in frequent contact, so that a jargon was produced, intelligible, as far as it went, to all. In it repetitions, too, were frequent. When the paucity of language furnishes the speaker with but one meagre word, the idea, so to express it, is longer than the word, and an unconscious desire exists to make up for the want by repetition. We see a somewhat similar process in the orator, who repeats the same idea twice or three times in different words, when the thought to be uttered is too pregnant to be despatched in one short sentence, which might indeed be sufficient in reading, but is not so for mere hearing; or in dull men, who repeat the same thing over and over, because they lack the energy of finishing, and cannot detach themselves from a thought which has once got possession of their sluggish intellect.

Very few of Laura's syllables can be written with our inadequate alphabet. This is natural. If missionaries among uncivilized tribes find the greatest difficulty in expressing words by alphabets which are even inadequate to their own languages—a difficulty of which the early christianizers of Germany complained—how much more unsuccessful must not be the attempt at writing many of Laura's unmodified and frequently inarticulate utterances. I think, however, I can say that the sounds of F, T, Pr, B, Ee, (German i,) and *Oo*, (French *ou*,) are prevailing, together with the sibilant *S*. The sound L, I discovered in one semi-guttural tone only, which might be approached by writing ***Lull***. I also observed the sound Pa—pa—pa, (for one of her best female friends;) Fif—fif—fif, (for a very lovely friend of hers;) Pig—pig—pig, (for a female teacher of hers;) and Ts—ts—ts, (for Dr. Howe.) I have also frequently heard her utter a sound between F and T. When she did not like to be touched, for instance, by boys, who often did it in a sportive mood, she would repeatedly utter F—generally in an equally sportive spirit; for, Laura is very fond of a joke, and greatly enjoys good-natured teasing.

Many of her sounds are gurgling, though not disagreeably so; others consist of a chuckling, and in general I would say that the throat and the lips seem to be the organs which she chiefly uses. The tongue is often pressed against the palate, producing a full, round, yet dull sound, which I cannot write. Vowels are very little used, and if so, generally indistinctly. The clear sonorous vowel in speaking and singing requires the ear and long civilization. Savages do not make frequent use of fine open vowels; and a bold singing from the chest gives way to nasal singing at a very late period only. All Asiatics to this day sing in this twang-chant, and so do the modern Greeks.

While I am writing these words, a tuneful mocking bird is pouring out its melodious song before my window. Rich and strong and mellow as is the ever-varying music of this sprightliest of all songsters of the forest, compared to the feeble and untuned sounds which Laura utters in her isolated state, yet her sounds are symbols of far greater import. She, even without hearing her own sounds, and with the crudest organs of utterance, yet has risen to the great idea of the Word. She wills to designate by sound. In her a mind is struggling to manifest itself and to commune with mind, revealing a part of those elements which our Maker has ordained as the means to ensure the development of humanity. The bird, with all its power of varied voice, remains forever in mental singleness; Laura, in all her lasting darkness and stillness, and with that solitary thread which unites her with the world without—the sense of touch—still proves, in every movement of her mind and urgency of her soul, that she belongs to those beings who, each in a different indestructible individuality, are yet fashioned for a mutual life, for sacred reciprocal dependence and united efforts.

Oliver Caswell, the blind deaf-mute at the same institution with Laura, utters but very few sounds. He has the same opportunities which she enjoys; but, though of an amiable temper, he is not endowed with a sprightly mind. He has one distinct sound, which he always uses to attract attention. It might be translated by the French *tiens*, or the English *I say*.

Julia Brace, the blind deaf-mute at Hartford, in Connecticut, above forty years old, and to whom no idea of a word-language has ever been imparted, utters many disagreeable sounds, not unlike those of some wild fowl. When she is pleased, without being excited, she produces a humming sound.

Anne Temmermanns, whom I saw in the year 1844, at Ghent—she was then twenty-four years old—uttered some, not agreeable, sounds, but she has none for different persons or things. Her whole education is much inferior to that of Laura or Oliver Caswell. I am not aware that there is anything valuable on record regarding the vocal sounds which James Mitchell, the blind deaf-mute Scottish boy, may have been in the habit of uttering. All these individuals were or are very different from Laura Bridegman, as well in natural endowments as in cultivation of mind and the developed state of the soul. I can never forget the contrast between the coarse and painful appearance of Anne Temmermanns and the intelligent Laura, as I have often seen her, seated by the side of a female friend, her left arm around the waist of her companion, and her right hand on the knee of the other, who was imprinting with rapidity in Laura's open hand what she was reading in a book before them. They thus formed the personification of the great achievement which Dr. Howe has gained over appalling difficulties, never overcome, and scarcely attempted to be overcome, by any one before him—the picture of a communion of minds in spite of the enduring night and deathlike silence which enwraps poor Laura—an example of the victories in store for a sincere love of our neighbor, combined with sagacity, patience, resolute will, and, what Locke calls, sound round-about common sense.

When the whole of this paper had been written many months, I read in the eighteenth report to the trustees of the Perkins Institution for the Blind, Boston, 1850, that Laura "often says, in the fulness of her heart, 'I am so glad I have been created.'" This psalm of gratitude, poured forth by her whom we pity as the loneliest of mortals—this hymnus of rejoicing in the possession of life—expresses infinitely more strongly and loudly what Dr. Howe has done for her than any praise of others could do.

The character of this paper does not permit us to pass from a scientific inquiry to moral reflections, which are forced upon us by this girl, grateful in her state, which appears to us one of overwhelming destitution; and thus we conclude the whole, leaving it to others to enlarge upon this remarkable and great text furnished by Laura: "I am so glad I have been created."

While thefore going paper was passing through the press, the writer received a letter from the untiring and able female teacher of Laura, answering a number of questions which I had made free to put to her regarding her pupil's mind, dispositions, and developments; and also one from Laura herself. The latter I mean to put here on record, as a remarkable document. Of the former I will give a very few extracts, interesting in reference to the subjects which have occupied us in this paper. Miss Wight writes to me:

"Before learning language Laura used many signs to make known her wants, and, as you know, for a long time gave to many of her friends names, which in some way were associated in her mind with the variety of their characters. She produces still the same sound for me that she made eight years ago, with this difference, that, originally, it was very soft and gentle; now it is louder and fuller, to correspond, as she says, with the change in myself. She no longer uses many of these names, and has forgotten a part of them. Mine she retains for its use," (calling, in the strict sense of the word, her teacher.) "She uses gestures expressive of different emotions. When she is merry, she often sings. When she says a humorous thing, she is not satisfied if the person addressed does not laugh heartily. She often talks with herself, sometimes holding long conversations, speaking with one hand and replying with the other.

"Laura is now in excellent health; very good and very happy. Your letters give her much pleasure. When I read your last to her the color mounted to her cheek, she laughed and clapped her hands."

The letter gives an interesting account of Laura's æsthetical feeling, her sense of symmetry, her conscientiousness, her affection for her mother, her religious state, sense of property, desire "to see this beautiful world," her love of power and strong will, yet ready submission to what is shown to her to be right, her skill in calculation, and of other subjects, all highly instructive, but not in close connexion with the subject immediately in hand. It is to be hoped that a general account of Laura's education will not much longer be withheld from the public.

I now shall give Laura's letter, word for word. There is not one word misspelled in it. Indeed spelling is her whole language. Sound and its representation are not at eternal war in her mind as in all our school-boys, and in the minds of not a few who no longer wear the round jacket. The reader must know that Laura writes her own letters, and does by no means dictate them. A fac-simile of her handwriting will be found at the end.

"Sunny Home, *Aug.* 15*th*, 1850.

My dear Dr. Lieber,

"I received your kindest letter with great pleasure last June in the P. M. I was very much interested in your account of the mocking bird. One very rainy tue. [for Tuesday] a very kind gentleman sent me 2 canary birds which looked very pretty and cunning. One bird died last June. The other bird seemed very quiet as if he missed his companion so sadly. He comforted himself by looking the glass, for he thought that he saw his companion there and used to sing to her. but at last he flew through the window which was opened a very short way, and left his cage desolate. A very kind friend promised me that he would send me a bird this week. I should be very glad to have you learn to talk with your fingers.

"I am highly delighted at the thought of going to Hanover to visit my dear Mother in Sept. Tell my dear Mrs. Lieber that I have got a little new Sister.

It has not received a name yet. My Mother writes that her babe resembles me very much. I am making a very nice white dress for the baby. I remember that Mrs. Lieber is very fond of children.

"Next Thursday will be 5 years since Miss W. commenced teaching me. I should like to get much better acquainted with you.

"Yours truly,

"L. BRIDGMAN."

I append to this Memoir a fac simile of a part of the following letter from Laura to Miss Dix, as an illustration of her writing. It should, however, be mentioned, that erasures, similar to the one which occurs in this letter, are very unusual in her manuscripts.

Sunny Home, *August* 21, 1850.

My Dear Friend, Miss Dix:

I was very glad to receive a long letter from you the 7th of August.

I thank you most sincerely for the card which you sent to me. I am very glad to think of your very pleasant acquaintance with Miss Bremer. I trust that she will meet with very good and pleasant people at Cape May. I prize my book very highly which Miss B. presented me with. I have not heard it all. I admire Franziska and her bear and Serena very much. I approve of Miss Bremer's taking her sea bath. I hope that it will be of benefit to her health. I do not doubt that the members of Congress would do much for the blind and deaf and dumb if they thought how much happier they are when they are educated.

I grieve very much to inform you that my lovely teacher was compelled to give up teaching. She went home for the purpose of regaining her strength. She planned some very pleasant visits for me before she left the Institution. I was rather home-sick occasionally during Miss W's absence. She is much better now; I am very well and happy.

I hope that you will write a letter to me again.

I send my best love to you.

Yours, truly,

LAURA BRIDGMAN.

Sunny home Aug 21st 18.80.

My dear friend Miss. Bia

I was very glad to receive a long letter from you the 7th of Aug.

I thank you most sincerely for the card which you sent to me.

I am very glad to think of your very pleasant acquaintance with Miss. Bremen. I trust that she will meet with ~~the~~ very good & pleasant people at Cape May:

I prize my book very highly which Miss. B. presented me with.........

Yours truly.

Laura. Bridgman.

MICROSCOPICAL EXAMINATION

OF

SOUNDINGS,

MADE BY THE U. S. COAST SURVEY OFF THE ATLANTIC COAST OF THE U. S.

BY PROF. J. W. BAILEY,

OF THE MILITARY ACADEMY, WEST POINT.

NAMES OF THE COMMISSION

TO WHICH THIS PAPER HAS BEEN REFERRED

Prof. Lewis R. Gibbes,
Prof. William B. Rogers.

MICROSCOPICAL EXAMINATION OF SOUNDINGS,

MADE OFF THE COAST OF THE UNITED STATES, BY THE

U. S. COAST SURVEY.

To JOSEPH HENRY, LL. D.,
Secretary of the Smithsonian Institution.

COAST SURVEY OFFICE,
Washington, *Dec.* 24, 1850.

SIR.

The accompanying paper, containing an examination, by Prof. Bailey, of the Military Academy, West Point, of specimens of the bottom of the sea, obtained in sounding between Montauk Point, New York, and Cape May, New Jersey, was presented to the meeting of the American Association of Geologists and Naturalists at Boston, by Prof. Agassiz, and its publication recommended. Besides the practical value to navigators of the examination of specimens of the bottom to ascertain the forms peculiar to different positions of our coast, the investigations of Professor Bailey have a scientific interest for the naturalist, and his descriptions, especially of new species, should be made known for the benefit of those engaged in similar pursuits. By authority of the Treasury Department, I, therefore, transmit the report of Prof. Bailey to you for publication in the Smithsonian Contributions to Knowledge, if on examination it is found to be of the proper character for insertion.

Very respectfully, your obedient servant,

A. D. BACHE,
Superintendent U. S. Coast Survey.

To Prof. A. D. Bache.
Superintendent of Coast Survey.

West Point, *March* 8, 1848.

Dear sir:

I propose in this communication to give you a more complete report of the results of my examination of the soundings which you kindly supplied me with, than I was able to do when I sent you a notice of my first hurried observations.

The specimens were each subjected to the following modes of examination:

1st. Inspection when dry with a pocket Stanhope lens.

2d. About a cubic inch of each specimen was placed in a watch glass with water, and agitated to bring the Polythalamia to the surface; the larger organic forms could then be easily picked up on the point of a needle and examined separately.

3d. Portions of the soundings were diffused in water on a glass slide, and when dried were coated with Canada balsam, and examined as transparent objects.

4th. By levigation the lightest particles were floated off, spread out on glass, and then coated with Canada balsam; by this means the infusorial remains were most easily detected.

By the above means the specimens yielded the results given below:

FIRST LINE OF SOUNDINGS.

Specimens from line E, about S. E. from Montauk Point.

E, No. 73, 13 fathoms; lat. 40° 59′ 35″; long. 71° 55′ 40″.

This specimen is quartzose sand with black specks. Nothing of interest was observed in it, and in consequence of its being mingled with grease the infusorial forms, if present, could not be detected.

E, No. 37, 19 fathoms; lat. 40° 59′ 55″; long. 71° 48′ 55″.

This is a coarse gravel, mingled with ash colored mud. By levigation it yielded a considerable number of silicious shells of Infusoria, among which were Gallionella sulcata, Coscinodiscus lineatus, C. excentricus, C. radiatus, Actinoptychus senarius, Actinocyclus quindenarius, Rhaphoneis rhombus, Triceratium alternans, Bailey; Grammatophora oceanica, Dictyocha speculum, Dictyopyxis cruciata; with spiculæ of Sponges or Alcyonia, small bivalve crustaceans, and a few small Polythalamia, chiefly species of Rotalina.

E, No. 7, 98 fathoms; lat. 40° 05′ 45″; long. 70° 55′ 35″.

This is a coarse clean sand, with black specks, with a few minute bits of shells. No Infusoria nor Polythalamia were detected in it.

E, No. 9, 51 fathoms; lat. 40° 21′ 54″; long. 70° 55′ 35″.

A greenish gray mud or fine sand, with a few bits of shells. It contains a considerable abundance of Polythalamia, among which were noticed Marginulina Bacheii, fig. 5, not abundant; Robulina D'Orbignii, fig. 9 and 10, and Bulimina auriculata, fig. 25 to 27.

SECOND LINE OF SOUNDINGS.

From line F, about S. E. from Fire Island Inlet.

F, No. 19, 11½ fathoms; lat. 40° 24′ 40″; long. 73° 41′ 20″.

This specimen is composed of a quartzose sand with black specks. It presented nothing of interest.

F, No. 27, 20 fathoms; lat. 40° 14′ 13″; long. 73° 21′ 20″.

In this were found numerous small plates of an echinoderm; also one spine of an Echinus, and a single specimen of Quinqueloculina occidentalis, Bail. See fig. 46 to 48.

F, No. 24, 49 fathoms; lat. 39° 52′ 40″; long. 72° 14′ 00″.

This is a greenish gray and rather coarse sand, mixed with some mud. By levigation it yielded a few spiculæ of sponges, a small cypriform crustacean shell, and one spine of an Echinus. Polythalamia are rather abundant in this locality, and among them were noticed Marginulina Bacheii, fig. 5, rather common; Orbulina universa, fig. 1, rare; a small Bulimina, and a few small specimens of Globigerina.

F, No. 25, 105 fathoms; lat. 39° 41′ 10″; long. 71° 43′ 00″.

This is a fine grayish green sand, very rich in small Polythalamia, particularly in the species of Globigerina represented in fig. 20 to 22; Marginulina Bacheii, fig. 5, is present, but rare; a triangular species of Textularia (T. atlantica Bail., fig. 38 to 43,) is also rather rare; the species of Rotalina (R. Ehrenbergii Bail.) represented in fig. 11 to 13, is quite common. By levigation this specimen yielded some spiculæ of sponges, fragments of Coscinodisci, one specimen of Triceratium alternans, fig. 55 and 56; many frustules of Gallionella sulcata, Ehr.; and some excessively minute spherical bodies (see fig. 49) which may possibly be the ova of Polythalamia.

THIRD LINE OF SOUNDINGS.

From line G, about east from Little Egg Harbor.

G, No. 12, 10 fathoms; lat. 39° 30′ 20″; long. 74° 10′ 40″.

In the coarse, clean, quartzose gravel, of which this specimen is chiefly composed, I noticed one small pebble of fossiliferous limestone, fig. 66, containing

well preserved plates from the column of a species of encrinite. The gravel also afforded two valves of Astarte castanea Say. By levigation it yielded a very small number of silicious Infusoria.

G, No. 27, 20 fathoms; lat. 38° 41′ 00″; long. 74° 06′ 00″.

A fine grained sand with black specks. A few fragments of bivalve and univalve shells, small spines, and numerous plates of an echinoderm, like those in F, No. 27, and some Polythalamia, were detected in this specimen. Among the Polythalamia were the Triloculina (T. brongniartiana? D'Orb.) represented in figs. 44, 45. The large species of Robulina (R. D'Orbignii, fig. 9 and 10) rather common, and several specimens of a minute species of Rotalina.

By levigation a considerable number of Infusoria were obtained, among which were Coscinodiscus lineatus, and undetermined fragments of other species. Actinocyclus in fragments also. Actinoptychus senarius, Gallionella sulcata, Stauroptera aspera, Striatella arcuata, a sigmoid Navicula, N. sigma Ehr., fig. 52, Dictyocha speculum, fig. 60, with some spicules of sponges. A few of the minute globular bodies, fig. 49, (eggs of Polythalamia?) were also seen.

G, No. 31, 50 fathoms; lat. 39° 20′ 38″; long. 72° 44′ 35″.

This sounding is composed of a fine grained grayish sand with much mud. It contains a considerable number of Polythalamia, among which were Marginulina Bacheii, rather common; Robulina D'Orbignii Bail., figs. 9, 10, Globigerina rosea? D'Orb., common, but not so much so as in F, No. 25.

The forms obtained by levigation were perfect discs of Coscinodiscus oculus-iridis, Triceratium alternans, fig. 55, Gallionella sulcata, and some spiculæ of sponges, fig. 58.

G, No. 8, 89 fathoms; lat. 39° 31′ 00″; long. 72° 11′ 20″.

Coarser than the last, not so muddy, and about the same color. It *abounds in Textularia atlantica*, fig. 38 to fig. 43, and in Globigerina, fig. 20 to 24; Marginulina Bacheii is also present; some specimens of Orbulina universa, fig. 1, and of Robulina D'Orbignii were also noticed.

Only a very small number of Infusoria were detected by levigation. These were, one specimen of Coscinodiscus patina, and a few frustules of Gallionella sulcata. A few silicious spiculæ, and some of the supposed ova of Polythalamia, fig. 49, were noticed.

FOURTH LINE OF SOUNDINGS.

From line H, southeast from Cape Henlopen.

H, No. 2, 10 fathoms; lat. 38° 46′ 40″; long. 75° 00′ 30″.

A fine sand, slightly muddy, containing a few small spines of an echinoderm, one specimen of Triloculina, and a few minute nautiloid Polythalamia.

By levigation a great variety of silicious Infusoria was obtained. The most interesting of the species were Rhaphoneis rhombus, and several undetermined species of the same genus, fig. 61 to 65, Triceratium favus Ehr., fig. 54, Coscinodiscus radiatus, C. excentricus, C. lineatus, Actinoptychus senarius, fragments of Actinocycli, Gallionella sulcata, Navicula sigma, fig. 52, a new species of Denticella? bearing two long spines on the middle portions of the terminal surfaces, see fig. 57; Dictyocha fibula, and D. speculum, fig. 60; sponge spiculæ, fig. 58, were also found.

H, No. 17, 20 fathoms; latitude 38° 29′ 56″; longitude 74° 38′ 04″.

A clean quartzose sand, coarser than the last, white and yellow, with black specks—no Polythalamia detected. By levigation a few Infusoria were found, among which were Coscinodiscus radiatus, C. excentricus, Gallionella sulcata, Stauroptera aspera, Striatella arcuata, Pennularia didyma, P. peregrina, Triceratium favus, fig. 54, Navicula lyra, Navicula sigma, fig. 52, and Dictyocha speculum, fig. 60. Soft parts of Polythalamia, retaining the form of the cells, were also noticed.

H, No. 67, 50 fathoms; lat. 38° 09′ 25″; long. 74° 04′ 05″.

A clean grayish sand, containing a few minute shells of Globigerina and Rotalina. The infusorial forms obtained by levigation were not abundant; among them were Coscinodiscus oculus-iridis, C. excentricus, Actinoptychus senarius, Gallionella sulcata, and Triceratium alternans, figs. 55 and 56.

H, No. 1, 90 fathoms; lat. 38° 04′ 40″; long. 73° 56′ 47″.

A rather coarse gray sand, with some mud, and containing a vast number of Polythalamia, particularly of Globigerina, many thousands of which must exist in every cubic inch of the sea bottom at this locality. Marginulina Bacheii, fig. 2 to 6; Globulina universa, fig. 1; Robulina D'Orbignii, figs. 9, 10; and Rotalina Ehrenbergii, fig. 11 to 13, are also common.

By levigation a few specimens of Coscinodiscus radiatus, Gallionella sulcata, and Triceratium alternans, figs. 55, 56, were obtained, with great numbers of the minute globular bodies, which I have supposed might be the ovæ of Polythalamia; they occur not only singly but in strings and bunches, as represented in fig. 49.

In water these bodies are easily seen, but when mounted in balsam they can scarcely be perceived, their cavity becoming nearly filled with balsam, and the thin shell almost vanishing from sight.

GENERAL RESULTS OF THE ABOVE EXAMINATIONS.

1st. The most remarkable fact determined by the examination of the above mentioned soundings is, that in all the deep soundings, from that of 51 fathoms S. E. of Montauk point, to that of 90 fathoms S. E. of Cape Henlopen, there is

a truly wonderful development of minute organic forms, consisting chiefly of Polythalamia, which occur in an abundance rivalling those vast accumulations of analogous forms constituting the marls under the city of Charleston, S. C.

2d. While there is a general resemblance between the species found in all the *deep* soundings above mentioned, the same species of Polythalamia occurring with few exceptions at each locality, yet each place has its predominant species; thus in the most southerly sounding, (H, No. 1, 90 fathoms,) there occurs a much greater number of Globigerina than in any of the others; while Textilaria atlantica, although present, is by no means so abundant as in "G, No. 8, 89 fathoms."

3d. Infusoria, as well as Polythalamia, occur in the deep soundings; but the infusoria are few in number, and consist of Coscinodisci, Gallionella sulcata, and other species, which probably swim freely in the ocean; while none of the littoral parasitic species, such as Achnanthes, Isthmia, Biddulphia, Striatella, and Synedra are found.

4th. It is worthy of notice that in the deep soundings not a single specimen was found of Polythalamia belonging to the Plicatilia of Ehrenberg, (Agathistiques of D'Orbigny,) while a number of these forms were found in the shallow soundings, and they are well known to occur in vast quantities around the shores of Florida and the West India Islands. This group of Polythalamia appears to have been created after the deposition of the chalk formation, in which no trace of such forms occur, while they are very abundant in the tertiary deposites. Their entire absence in the deep soundings, where vast numbers of other Polythalamia occur, and their presence in littoral deposits, would seem to indicate that for their abundant development comparatively shallow seas are necessary; thus affording additional evidence of difference in the depths of the seas from which the cretaceous and tertiary beds were deposited.

5th. The deep soundings were all from localities which are more or less under the influence of the Gulf stream, and it is not improbable that the high temperature of the waters along the oceanic current may be cause of immense development of organic life, making its path, as is shown by the soundings, a perfect milky way of Polythalamia forms. The deposits under Charleston may have been produced under the similar influence of an ancient gulf stream.

6th. From the presence of such great numbers of Polythalamia in the deep soundings, there results a very large proportion of calcareous matter, thus presenting a striking difference between them and the quartzose and felspathic sands nearer shore.

7th. The littoral sands obtained in shallow soundings at first view appear to afford little promise of affording any Infusoria. But notwithstanding their coarse, and, in some cases, even gravelly nature, they all yield by levigation a considerable number of silicious Infusoria, which in variety and abundance exceed those found in the deep soundings.

8. None of the soundings present anything resembling the vast accumulations of Infusoria which occur in the Meiocene infusorial marls of Virginia and Maryland; and, indeed, I have never found, even in estuaries, any recent deposit at

all resembling the fossil ones, in abundance and variety of species, with the exception of the mud of a small creek opening into the Atlantic near Rockaway, Long Island.

9th. The occurrence of the pebble of limestone with encrinal plates in the gravel of F, No. 10, S. E. of Little Egg Harbor, is of some interest, as the nearest beds from which it could have come are the Silurian formations of Pennsylvania or northern New Jersey. It indicates a transportation of drift to a considerable distance sea-ward.

10. In addition to the quartzose grains in the soundings, fragments of felspar and hornblende (recognisable under the microscope by their cleavage planes and color) are found. The quartz, however, predominates, its grains being sharp and angular in the deep soundings, and often rounded or even polished in the shallower ones.

DESCRIPTION OF THE MOST INTERESTING MICROSCOPIC FORMS FOUND IN THE ABOVE MENTIONED SOUNDINGS.

In this description, I have adopted for the Foraminiferæ the generic characters given by Alcide D'Orbigny in his splendid work "Foraminifères fossiles du Bassin Tertiaire de Vienne." With regard to the infusorial forms I have, of course, taken Ehrenberg as my guide.

FORAMINIFERÆ, *D'Orbigny.*

(POLYTHALAMIA, *Ehrenberg.*)

Genus Orbulina. Shell free, regular, spherical, hollow, perforated with minute holes which are only visible when greatly magnified. Aperture single, small, rounded, without projection or radiant lines.

Orbulina universa, D'Orb., (fig. 1.) Only one species of thisgenus has been distinguished, and this appears to be a cosmopolite species, occurring in the Adriatic and Mediterranean seas, at the Canary Islands, and in East and West Indies. It also occurs fossil in Italy and Austria.

It is not a rare form in the deep soundings described in this paper.

Genus Nodosaria, D'Orb. Shell, free, regular, elongated, straight, rounded, or flattened; cells rounded, distinct, but slightly envelloping, separated by deep constrictions, the last always convex, often elongated; axis imaginary, straight; aperture rounded, small, placed at the termination of a prolongation of the last cell.

Several fragments of different species of this genus were noticed in the deep soundings, but none were sufficiently perfect to give good specific characters. Fig. 8 represents one of these fragments, which was very smooth and vitreous in its appearance.

Genus Dentalina, D'Orb. Shell much elongated, slightly arcuate, smooth, slender, formed of long oblique cells, gradually increasing in size; aperture small, round, in the acuminated end of the last cell.

Dentalina mutabilis, Bail., (fig. 7.) Shell composed of slightly convex smooth cells, which are variable in length, a short one often succeeding a longer one; aperture surrounded by radiant ridges. Several fragments were found in the deep soundings labelled No. 1, H, 90 fathoms.

Genus Marginulina, D'Orb. Shell free, regular, equilateral, elongated, arcuate, often curved at the posterior extremity in form of a crosier, formed of globose partially envelloping cells, the last of which is always convex, and often prolonged; the first cells turned backwards, and often showing an approach to a spiral arrangement; imaginary axis arcuate, the convexity on the same side as the opening; aperture rounded, usually placed at the extremity of an elongation of the last cell.

Marginulina Bacheii, Bail., figs. 2, 3, 4, 5, and 6. Shell elongated, smooth, and shining, formed of cells, the first of which are arranged in a spiral manner, and compressed laterally; the others gradually assume a more globular form, and an oblique position, giving to the whole shell a sigmoid form; aperture at the elongated extremity of the last cell, surrounded by small ridges.

This fine species is one of the largest and most conspicuous forms in these soundings. It was found in considerable numbers in all the soundings except the shallow ones, from S. E. of Montauk Point to S. E. of Cape Henlopen.

I take pleasure in dedicating this species to Prof. A. D. Bache, Superintendent of the Coast Survey. Fig. 2, side view of the young shell; fig. 3, front view of the same; fig. 4, end view of the same, showing the orifice; fig. 5, the full grown shell; fig. 6, end view, showing the orifice.

Genus Robulina, D'Orb. Shell free, regular, equilateral, suborbicular, much compressed, carinate, vitreous, shining, formed of elongated cells, constantly arranged in an envelloping spiral, and uniting in the region of the umbilicus. Aperture triangular, longitudinally cleft, situated at the carinal angle of the cells.

Robulina D'Orbignii, Bail., (fig. 9, 10,) shell discoidal, compressed, with a narrow but sharp carina, surface free from ridges, cells about eight in number, with traces of the successive apertures visible on the three or four last. Aperture a longitudinal cleft surrounded by small ridges. It occurs in considerable numbers at all the localities mentioned as furnishing the Marginula Bacheii. I dedicate it to Alcide D'Orbigny, who, by his labors, may be said to have created the important and interesting branch of science to which these minute shells belong.

Genus Rotalina, D'Orb. Shell free, depressed or trochoid, minutely perforated, often carinate, formed of a depressed spire, truncate or conical, composed of depressed cells, pierced with an aperture in the form of a longitudinal cleft, on the side of the penultimate turn of the spire, occupying but a portion of the last cell.

Rotalina Ehrenbergii, Bail,. figs. 11, 12, 13. Shell orbicular, depressed, nearly

plain above, very convex and slightly umbilicate below. Spire having three or four turns composed of oblique cells, about nine of which compose the last turn. Aperture elongated, somewhat lunate, commencing near the angle of the outer cell, and extending to near the middle of the inner margin. Near to *R. Soldanii D'Orb.* It occurs rather frequently in the soundings No. 25 F, 49 fathoms, but also occurs in several of the deeper soundings. I have named it in honor of the Prince of Microscopists.

Rotalina cultrata ? D'Orb, figs. 14, 15 and 16. Shell punctate, depressed, spire composed of about five cells, each of which has a conspicuous raised border, which on the outer margins form a carinate edge to the cell. Our species appear to differ from the R. cultrata of D'Orbigny in having the carina slightly rounded, instead of presenting the acute cultrate edge represented in Pl. 5, fig. 9, Foraminiféres des Antilles.

It is quite a common form in the deep soundings.

Rotalina semipunctata, Bail., figs. 17, 18, 19. Shell somewhat irregular, having six cells visible in the upper surface, which are marked with numerous deep perforations on their upper surface, but are smooth and imperforate below. Aperture lunate, with a raised margin. Occurs in the soundings marked G. No. 28, 89 fathoms.

Genus Globigerina, D'Orb. Shell free, spiral, globose, always rugose, and perforated with minute holes. Cells few in number, spheroidal, arranged spirally. Aperture generally crescent shaped, situated at the umbilical angle near the axis of the spiral.

Globigerina rubra, D'Orb., (figs. 20, 21, 22) ? figs. 23, 24. Shell elevated, spire composed of one turn and a half, or in the adult shell of five cells only. Cells spherical, very distinct, three of which form the last turn of the spiral. Besides the usual aperture, two others are sometimes visible in the last cell, and one on the last but one.

The last cells are yellow, or yellowish red; while near the summit of the spire the red tint predominates.

Vast numbers of one or more species of Globigerina occur in some of the soundings referred to above, being particularly abundant in those marked F. No. 25, 105 fathoms, and H, No. 1, 90 fathoms. They are common also in those marked G, No. 31, 50 fathoms, and H, No. 67, 50 fathoms, while they are few and small in F, No. 24, 49 fathoms. Some of them, by their red color and other characters, are decidedly referable to G. rubra of D'Orbigny. Others like figs. 20 to 22, which are white and have a more elongated aperture, may belong to a different species. The abundance in which these species of Globigerina occur in the deep soundings, G, No. 31 and H, No. 1, gives to these green muds a most striking resemblance to the green tertiary marls perforated by the Artesian wells at Charleston, S. C. This similarity appears to indicate that the Charleston beds were a deep sea deposite, perhaps made under the influence of an ancient Gulf stream.

Genus Bulimina, D'Orb. Shell free, spiral, turriculated, formed of an elongated spire composed of cells which are arranged in a regular spiral axis, project but little, are more or less envelloping, and the last of which is not prolonged into a tube. Aperture longitudinal, comma shaped, or rounded, lateral on the internal edge, or near the superior angle of the last cell.

Bulimina auriculata, Bail., figs. 25, 26, and 27. Shell ellipsoidal, smooth or very minutely punctate, sutures not very distinct. Aperture with an ear-shaped appendage.

Several of these were found in the soundings marked No. 9, 51 fathoms.

Figs. 25 and 26 show the general form of the shell, and fig. 27 represents the lower part of the shell with the auricular appendage more highly magnified.

Bulimina turgida, Bail., figs. 28 to 31. Shell ovoidal, smooth, and having several small dentate projections at the apex; cells much inflated, separated by deep sutures, aperture nearly symmetrical, with a raised border.

Found in the soundings marked No. 9, 51 fathoms, and F, No. 24, 49 fathoms.

Figs 28, 29, and 30 show different portions of the same individual. Fig. 31 shows the lower part of fig. 28 more highly magnified.

Bulimina serrata, Bail., figs. 32, 33 and 34. Shell minute, pyramidal, the sutures, particularly in the upper part of the spire, strongly marked and serrated. I noticed several of these very minute shells in the soundings No. 9, 51 fathoms, and G, No. 31, 51 fathoms.

Fig. 32 and 33 show two positions of the same shell; fig. 34 shows the lower part of fig. 32 more highly magnified.

Bulimina compressa, Bail., figs. 35, 36 and 37. Shell elongated, somewhat pyramidal, slightly compressed laterally, aperture a long cleft without any very distinct margin. Occurs in "F, No. 24, 49 fathoms," in "F, No. 25, 105 fathoms," and in "G, No. 31, 50 fathoms."

Figs. 35 and 36 show two positions of this shell, and fig. 37 represents the lower part of fig. 36 more highly magnified.

Genus Textularia, Defrance (*Textilaria* Ehr.) Shell free, regular, equilateral, conical, oblong or wedge shaped, rugose or agglutinating; formed of globular or wedge shaped cells, which regularly alternate at all ages on each side of a longitudinal axis, and which are either partially envelloping, or are only superposed on two alternate regular lines. Aperture semi-lunar, transverse, lateral on the interior side of the last cell.

Textularia atlantica, Bail., figs. 38 to 43. Shell large, pyramidal, three sided, with one side flattened and the other two rounded and convex, having three edges or carina, strongly marked near the apex of the shell, but one of which (separating the two convex sides) nearly disappears on the lower part. Surface quite rugose, color greyish. Aperture lunate, with a depressed margin.

This large and well characterized species so much resembles to the naked eye a fragment of gravel or sand, that it may be easily overlooked in soundings where it is quite abundant, but when once seen it is easily recognised, even

without the aid of a magnifier. It appears to exist only in the deep soundings, and is *particularly abundant* in those marked G, No. 8, 89 fathoms.

None of the species of Textularia, which are so abundant in our tertiary marls, have been found by me during the examination of these soundings.

Genus TRILOCULINA, D'Orb. Shell free, inequilateral, globular or compressed, having the same form at all ages, formed of enveloping cells developed on three opposite faces, so that three cells only are visible; their cavity is simple. Aperture single, round or oval, placed alternately at one or the other end of the longitudinal axis, and furnished with a more or less complicated tooth.

Triloculina brongniartiana, (figs. 44, 45)? Shell oblong, convex, a little gibbose with fine longitudinal striæ, obtuse posteriorly, acuminate and rostrate anteriorly, outline convex, not at all angular. Cells arcuate, gibbose, rounded behind, gradually diminishing in diameter in front up to the anterior portion, when they suddenly contract to form the slender prolongation for the aperture. Aperture small, round, with a small simple obtuse tooth.

This description of a species common in the West Indies, appears to suit in most respects the species represented in figs. 44 and 45, which was found in No. 27, 20 fathoms.

Genus QUINQUELOCULINA, D'Orb. Shell free, inequilateral, globular or compressed, rounded or angular, having the same form at all ages, formed of enveloping cells developed on five opposite faces, so that five only are visible. Cavities simple. Aperture single, with a simple or compound tooth.

Quinqueloculina occidentalis, Bail., figs. 46, 47, and 48. Shell elliptical compressed, not angular, of a smooth and porcellaneous texture. Aperture moderately large, with a simple robust tooth.

Found in the soundings marked F, No. 27, 20 fathoms, and not uncommonly in the sands along the Western shores of the Atlantic.

OVA OF POLYTHALAMIA?

The minute globular bodies, represented highly magnified in fig. 49, are particularly abundant in the soundings No. 1, 90 fathoms, S. E. of Cape Henlopen. They also occur, though less abundantly, in the other deep soundings; they are found most easily when a portion of the mud is diffused in water, for when mounted in Canada balsam, their refractive power is so nearly that of the balsam, that they become almost invisible. Their real nature is wholly unknown to me, but from their occurrence with the Polythalamia, and their resemblance in form and size to the globular bodies sometimes found in the fossil Polythalamia which have been supposed to be the fossil ova of these minute animals,* it is not improbable that these may be the eggs in a recent state.

*See the interesting memoir on the fossil remains of the soft parts of Foraminifera, by Dr. Mantell, Phil. Trans., Part IV for 1846, and Silliman's Journ., vol. 5, p. 70, new series.

INFUSORIA.

I shall not enter into a detailed description of the Infusoria found in these soundings, as the species detected were mostly such as are well known, and which have a wide geographical range. In the deep soundings they consisted chiefly of species of the genera Coscinodiscus, Actinocyclus, and Actinoptychus, for figures of which reference may be made to figs. 10 to 15 of the second plate of my memoir on American Bacillaria.

Some of the other interesting forms are represented in the plate accompanying this memoir. The following brief account of them, it is believed, will be sufficient:

Fig. 50. This appears to be the *Dictyopyxis cruciata* of Ehrenberg. It resembles two thimbles joined together, with the whole surface covered with minute cells, or projections so arranged as to give the appearance of two sets of lines crossing each other obliquely.

It occurs in No. 37, 19 fathoms, and is also a common fossil in Virginia.

Fig. 51. This is a species of *Pinnularia*, probably new.

Fig. 52. *Navicula sigma*, Ehr.?

Fig. 53. *Periptera* sp.? Found in No. 37, 19 fathoms. Closely allied forms are common among the fossil Infusoria of Virginia.

Fig. 54. *Triceratium favus*, Ehr. An elegant cosmopolite species, easily recognised by its large triangular form and hexagonal cells. I have found it along our coast from Rockaway, Long Island, to Charleston, South Carolina.

It also occurs in the mud of the Hudson river at West Point, and has also been found in Europe and Asia. It has not yet been detected in the fossil state.

Fig. 55. *Triceratium alternans*, Bailey. I attach this provisional name to the species represented in figs. 55 and 56. It is much smaller than the preceding species and chiefly characterized by the three curved lines seen on its triangular face, as represented in fig. 56. It occurs in both shallow and deep soundings, and also as a fossil.

Fig 57. An interesting and probably novel form referable, I think, to Ehrenberg's genus *Denticella.* The figure shows its form with sufficient accuracy, but in consequence of its surface being obscured, I could not well make out the character of the minute markings of the shell. For the present I shall call it *Denticella dubia.*

It was found in H, No. 2, 10 fathoms, S. E. of Cape Henlopen.

Fig. 58. Spicules of sponges, common in all soundings.

Fig. 59. Frustule of *Grammatophora oceanica?* common in shallow soundings.

Fig. 60. *Dictyocha speculum*, Ehr. Common in shallow soundings; occurs occasionally in deep soundings, and is also a common fossil species.

Fig. 61 to 65. Different species (?) of Ehrenberg's genus *Rhaphoneis.* These were all found in the sounding H, No. 2, 10 fathoms, and are chiefly of interest from their resemblance to species occurring abundantly in the fossil state in the Meiocene infusorial strata of Maryland and Virginia.

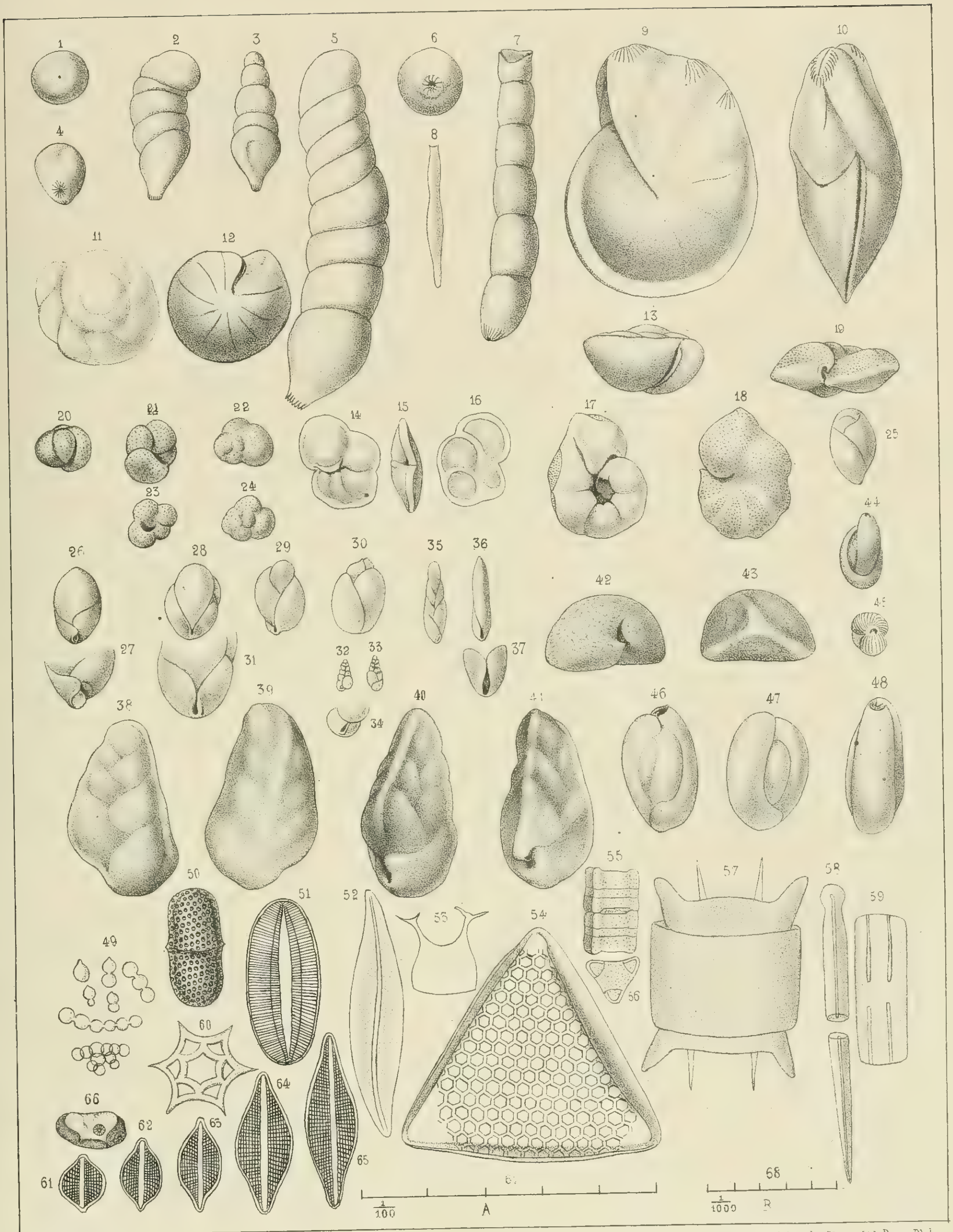
Fig. 66. Pebble of fossiliferous limestone, containing encrinal plates found in the soundings marked No. 12, 10 fathoms.

Fig. 67. Scale A, represents $\frac{5}{100}$ths of an English inch equally magnified with the drawings from fig. 1 to fig. 48, (excluding figs. 27, 31, 34, and 37.)

Fig. 68. Scale B, represents $\frac{5}{1000}$ths of an inch equally magnified with the figures from fig. 49 to fig. 65 inclusive.

It is not without much hesitation that I have ventured to attach specific names to some of the forms above described, but for the purposes of this paper it was thought that these provisional names would be more convenient than mere references to the figures. I trust that the figures themselves, which were all drawn by the aid of a camera lucida, will be found sufficiently accurate to enable naturalists interested in this subject to identify the species.

Published by the Smithsonian Institution, January, 1851.



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P. S. Duval's Steam Lith. Press Phil.

MICROSCOPIC FORMS IN SOUNDINGS MADE BY THE U.S. COAST SURVEY.

CONTRIBUTIONS

TO

THE PHYSICAL GEOGRAPHY OF THE UNITED STATES.

PART I.

OF THE PHYSICAL GEOGRAPHY OF THE MISSISSIPPI VALLEY,

WITH SUGGESTIONS FOR THE IMPROVEMENT OF THE

NAVIGATION OF THE OHIO AND OTHER RIVERS:

BY CHARLES ELLET, JR., CIVIL ENGINEER

[RECEIVED, SEPTEMBER 17, 1849.]

GIDEON, PRINTER.

NAMES OF THE COMMISSION

TO WHOM THIS MEMOIR HAS BEEN REFERRED.

Major ALFRED MORDECAI, - - - *Ordnance Dept.*, *U. S. A.*
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Lieutenant M. L. SMITH, - - - *Topographical Corps*, *U. S. A.*

JOSEPH HENRY,
Secretary of the Smithsonian Institution.

WASHINGTON, D. C.
December, 1849.

OF THE PHYSICAL GEOGRAPHY OF THE

MISSISSIPPI VALLEY,

WITH SUGGESTIONS FOR THE IMPROVEMENT OF THE NAVIGATION OF THE

OHIO AND OTHER RIVERS.

THERE are few studies which exhibit beneficent design in a more impressive form than that which unfolds the adaptation of the physical structure of the earth to the wants of man. The mountains, plains, and valleys, the harmony of coloring, and all that appertains to the beauty of structure, speak to the eye and require no aid from science to impress the imagination. The fertility of the soil supplies the necessaries of life, and calls for acknowledgment and praise. The stores of mineral wealth, formed for ages in advance, to be called forth in due season to aid in the support of industry, the developments of art, and the progress of civilization, are so essential to all the movements of the machinery of society, that the wisdom which ruled their formation and prepared the treasure could scarcely fail to inspire a tribute of admiration.

But the great features of the physical formation of the earth, the distribution of hills and mountain ranges, on which the clouds may break and condense into rain; the arrangement of the gentle plains that spread out from the base of each hill and mountain, until they intersect other plains which spread out from other hills and other mountains, and form channels at their intersection for the drainage of the surplus water shed from the adjacent slopes; the adaptation of these valleys by a happy combination of the dip towards the ocean, the area drained, and the development of the stream to navigation and the wants of commerce, and the convenience of cultivated man—these are the studies of science, which require the aid of art and its improvements.

There are few divisions of the earth which offer more beautiful illustrations of this adaptation of natural means to an obvious purpose, than the physical geography of that portion of the United States which lies between the Great

Lakes and the Gulf of Mexico, and extends from the Atlantic to the Rocky mountains.

From the summit of these mountains a great plain slopes gently to the east, along which flow all the streams that enter the lower Mississippi and the Gulf of Mexico, from the west. Another plain, of nearly equal extent, and equally gentle in its inclination, descends from the north, along which flow the northern tributaries of the Ohio and the Mississippi itself, until it unites with the great Missouri, flowing along the irregular line which marks the intersection of these vast surfaces; while another plain, descending from the summit of the Alleghany range, conveys the waters of the Cumberland and Tennessee, and all the southern tributaries of the Ohio, and intersects the great plain from the north, in the valley of the Ohio, and the greater plain from the west, in the valley of the lower Mississippi.

The intersection of the great slopes from the south and east with those from the north and west, near the confluence of the Mississippi, Missouri, and Ohio, creates what deserves to be regarded as a geographical centre of this remarkable region—a position which is rapidly becoming, from causes depending upon its physical geography almost entirely, the centre of commerce, wealth, and population, of the whole North American Continent.

A single plain spreads from the summit of the Alleghany mountains to the Atlantic coast, and turning the northern and southern flanks of that range, runs into the slope which sustains the southern tributaries of the Ohio.

The word *plain* is adopted here for the convenience of description only, and is not to be received in a literal sense. These great surfaces are furrowed by valleys, and relieved in places by hills and even mountains; yet these mountains are of inconsiderable extent compared with the vast area of the region described, and rest upon the great slopes which descend from the dividing ranges.

The Alleghany mountain is thus an elevated centre, from which the land descends and the waters flow in all directions. Where it approaches the coast most nearly, in Pennsylvania and Virginia, the fall is rapid and the rivers of quick descent. They are therefore difficult of navigation; but as their development is short, they are less needed for navigation.

On the reverse, or western side of this elevated range, the sources of the streams and the land which their waters irrigate and fertilize are far from the ocean, the great recipient of their commerce. And nature has here provided for the future necessities of an enterprising and improving race, by giving the streams which are to float the products of toil a greater space to glide over, a longer development, and a descent just sufficient to carry off the surplus water, with a current so gentle that it may be stemmed by the power which the genius of man is capable of calling into operation.

This law prevails throughout the globe. Those countries which are far from the ocean have long and gentle rivers, serving to drain off their surplus water, and to bear their surplus products. The sides of the mountains which front towards the ocean are abrupt and steep, their valleys are narrow and precipi-

tous, and their surface rugged. While the opposite sides of the same mountains, looking into the interior, are comparatively gentle, seamed with long valleys which form the tributaries of the navigable rivers that there commence their course to the distant ocean.

The Andes descends abruptly to the Pacific, which it reaches in a short distance, discharging from its sides small but rapid streams that run into falls and cataracts; while the long plain which slopes up slowly from the Atlantic, and forms the beds of the Amazon and La Plata, rises far on the sides of the mountain before the mountain itself becomes a distinct elevation.

It seems to be a rule in the natural economy, that countries remote from the ocean shall have outlets through great rivers of slow descent; rivers which serve primarily for their drainage, but so formed that they might be used, in the progress of time, for the highways of civilization. The plains of China are thus supplied with the Amour, Russia with the Volga, Germany has the Danube, Brazil and the States east of the Andes, the Amazon, Orinoco, and La Plata; all rivers of gentle descent, leading far into the interior, and all adjusted for navigation.

The Mississippi, Missouri, and Ohio, with their great arms, are the guerdon bestowed upon the central valley of the United States. The physical characteristics and capabilities of some of these it is here proposed to study.

OF THE OHIO.

In tracing the Ohio to its source, we must regard the Alleghany as its proper continuation.

This noble tributary rises on the borders of Lake Erie, at an average elevation of 1,300 feet above the surface of the sea, and nearly 700 above the level of the lake. The plain along which this river flows is connected with no mountain range at its northern extremity, but continues its rise, with great uniformity, from the mouth of the Ohio to the brim of the basin which encloses Lake Erie. The sources of the tributary streams are generally diminutive ponds, distributed along the edge of the basin of Lake Erie, but far above its surface, and so slightly separated from it, that they may all be drained with little labor down the steep slopes into that inland sea.

From these remote sources a boat may start with sufficient water, within seven miles of Lake Erie, in sight sometimes of the sails which whiten the approach to the harbor of Buffalo, and float securely down the Connewango, or Cassadaga, to the Alleghany, down the Alleghany to the Ohio, and thence uninterruptedly to the Gulf of Mexico. In all this distance of 2,400 miles, the descent is so uniform and gentle—so little accelerated by rapids—that when there is sufficient water to float the vessel, and sufficient power to govern it, the downward voyage may be performed without difficulty or danger in the channels as they were formed by nature; and the return trip might be made with equal security and success with very little aid from art.

And such is also the characteristic of many of the smaller ramifications of the head waters of the Alleghany, which do not rise on the borders of Lake Erie. They still descend so gradually and uniformly that they may be safely traversed by rafts and boats when reduced to a width of only 12 or 15 feet.

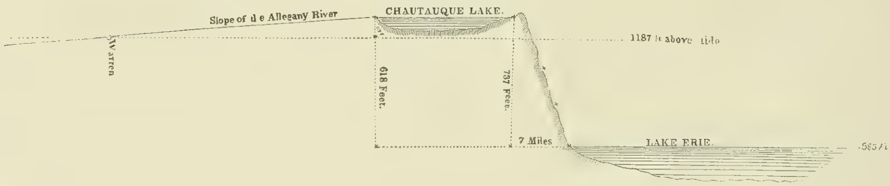
The elevation of the Alleghany at Olean Point, 250 miles above Pittsburg, as determined by the surveys of the writer, is 1,403 feet above tide. Steamboats have ascended to this point in sufficient water—2,300 miles from the mouth of the Mississippi—and might, by a little labor, be capable of running there at all times.

The following figure is a profile of the Alleghany and the outlet of Chautauque lake, one of its tributaries, showing the physical formation of the district connecting the head waters of the Ohio with Lake Erie.

Horizontal scale—20 miles to the inch.

Vertical scale—800 feet to the inch.

FIG. I.



An inspection of this diagram will exhibit the plain along which flow some of the northern tributaries of the Ohio, and the sudden depression below that plain of the basin which contains Lake Erie. It is a correct representation, drawn from the actual surveys of the writer.

The upper Alleghany and its tributaries, traced towards their sources, rise very uniformly at the rate of about 3 feet per mile, and terminate in a number of small lakes, of which the Chautauque is the most important, and separated like the others by a narrow ridge from the basin of Lake Erie. An excavation only 60 feet deep through this ridge would turn one of the principal tributaries of the Ohio into Lake Erie and the St. Lawrence.

Tracing the Ohio river from Coudersport, which is some 40 miles above the extreme limit of the natural steamboat navigation of the Alleghany, to the entrance of the Mississippi into the Gulf of Mexico, we find the following rate of descent from point to point:

TABLE I.

DESCENT OF THE ALLEGHANY, OHIO, AND MISSISSIPPI RIVERS.

	DISTANCES.	FALL.	FALL PER M.	
	Miles.	Feet.	Feet.	Inches.
From Coudersport to Olean Point - - - - -	40	246	6	2
" Olean Point to Warren - - - - - -	50	216	4	4
" Warren to Franklin - - - - - - -	70	227	3	3
" Franklin to Pittsburg - - - - - - -	130	261	2	
" Pittsburg to Beaver - - - - - - -	26	30	1	$1\frac{85}{100}$
" Beaver to Wheeling - - - - -	62	49	-	$9\frac{50}{100}$
" Wheeling to Marietta - - - - - - -	90	49	-	$6\frac{53}{100}$
" Marietta to Le Tart's Shoals - - - - -	31	16	-	$6\frac{17}{100}$
" Le Tart's Shoals to the mouth of Kanawha - -	55	33	-	$7\frac{20}{100}$
" Mouth of Kanawha to Portsmouth - - -	94	48	-	$6\frac{13}{100}$
" Portsmouth to Cincinnati - - - - - -	105	42	-	$4\frac{80}{100}$
" Cincinnati to Evansville - - - - - -	328	112	-	$4\frac{10}{100}$
" Evansville to the Gulf of Mexico - - - -	1365	320	-	$2\frac{813}{1000}$
" Coudersport to the mouth of the Mississippi -	2446	1649		

The descent of the Ohio, from point to point, exhibited in this table, is derived from the labors of numerous civil engineers, whose surveys, carried across the States of New York, Pennsylvania, and Virginia, to the Ohio river and Lake Erie, and from Lake Erie through the States of Indiana and Ohio, are the only reliable sources from which we can yet determine the entire fall of this great commercial highway.

The differences of the elevations at low water of the Ohio at Pittsburg, Wheeling, and Le Tart's Shoals, are from a hydrographical survey made under the direction of the United States Topographical Bureau.

The elevation of Olean Point in the State of New York, and the heights of all other places in that State, referred to in this paper, were obtained from a survey, conducted by the writer in the first location of the western division of the New York and Erie Railroad, in 1839. That of Point Pleasant, at the mouth of the Great Kanawha, was also obtained from a survey made by the writer in 1838, for the James river and Kanawha improvement in Virginia; which survey was carried from tide water at Richmond, across the Alleghany mountains, to low water in the Ohio, and tested effectually from point to point.

The levels of the Alleghany at Coudersport and Warren are computed from facts obtained from the survey of the Sunbury and Erie Railroad, made in 1839, under the direction of Edward Miller, esq., civil engineer.

The elevation of low water in the Ohio at Pittsburg is variously stated by different authorities. Preference is here given to the levels made under the direction of Messrs. Nathan S. Roberts, and Alfred Cruger, in 1829, for the Chesapeake and Ohio Canal Company.

The elevation of the low water surface of the Mississippi, at the mouth of the Ohio, is derived from the recent survey of the Mobile and Ohio railroad, made under the direction of Captain John Childe, civil engineer.

The level of Lake Erie which forms the basis for the determination of heights west of the Ohio, was first correctly obtained in the location of the Erie canal, and reported at 565 feet above tide.

The elevation of that lake, as determined by the survey of the New York and Erie Railroad, was 569 feet above tide.

The following table exhibits the elevations of prominent points along the Ohio and Alleghany rivers above the level of the Atlantic. The writer regrets his inability to give to the respective engineers by whom the surveys were made proper credit for their labors.

TABLE II.

ELEVATIONS OF THE OHIO RIVER AT LOW WATER.

	FEET ABOVE TIDE.
Mouth of Ohio, above high tide, in Gulf of Mexico - -	275
Mouth of Wabash, (approximately) - - - -	297
Evansville, (approximately) - - - - - -	320
New Albany, below the Falls - - - - - -	353
Louisville, above the Falls - - - - - -	377
Cincinnati - - - - - - - - - -	432
Portsmouth - - - - - - - - - -	474
Mouth of Great Kanawha - - - - - -	522
Head of Le Tart's Shoals - - - - - -	555
Marietta, (mouth of Muskingum) - - - - -	571
Wheeling - - - - - - - - -	620
Pittsburg - - - - - - - - -	699
Franklin - - - - - - - - -	960
Warren - - - - - - - - -	1,187
Chautauque Lake - - - - - - - -	1,306
Olean Point - - - - - - - - -	1,403
Mouth of Oswaya - - - - - - - -	1,419
Smithport - - - - - - - - -	1,480
Coudersport - - - - - - - - -	1,649
Surface of Lake Erie - - - - - - -	565

Cairo, at the mouth of the Ohio, is computed to be 1,178 miles from the Gulf of Mexico. The descent of the Mississippi, from the mouth of the Ohio to the Gulf of Mexico, is therefore $2\frac{8}{10}$ inches per mile, at low water.

From Cairo to Pittsburg the ascent is 424 feet, and the computed distance 975 miles. The average inclination of the Ohio is therefore $5\frac{218}{1000}$ inches per mile.

From Pittsburg to Olean Point the ascent is 704 feet, and the computed distance 250 miles. The average inclination is therefore 2 feet 10 inches per mile.

The distances from point to point along these rivers are not obtained from actual survey, but are the computed distances as they are estimated by watermen, or laid down in the rough charts of the river. While, therefore, we may regard the elevations of the low water surface of the stream as correctly ascertained, we can only consider the fall per mile, deduced from these computed distances, as close approximations.

The descent of the Mississippi, below the mouth of the Ohio, at low water, may be confidently taken, as above, at an average of $2\frac{8}{10}$ inches per mile; and that of the Ohio, from Evansville to its confluence with the Mississippi, at about $2\frac{9}{10}$ inches per mile.

It has been suggested that the waters of the Gulf of Mexico stand much higher than those of the Atlantic on the spheroidal surface of the earth; for the reason that the Gulf stream, setting always towards the north, must have a certain descent to account for its current. That current can only be due to a certain head at the source of the stream, since water in an open channel flows only in virtue of the inclination of its surface. But the levels in the foregoing table, which have been carried from the Hudson to the mouth of the Wabash, and from the Gulf of Mexico to the mouth of the Ohio, agree so closely, that, while we cannot dispute the theory, it is impossible, yet, to detect the fact.

By observing the descent of the Alleghany from Franklin to Pittsburg, we may conclude, that rivers, of which the fall does not exceed two feet per mile, are navigable for steamboats, unless there be great irregularity in the distribution of that fall. In the event of such irregularity existing, rivers having an average descent not exceeding two feet per mile, if well supplied with water, must afford exceedingly good navigation between the rapids, which must be very remote and easily overcome.

We learn, also, from these tables, that a descent of nearly *four feet per mile* is not incompatible with the existence of steamboat navigation, if the supply of water be well maintained; for a steamboat has ascended the Alleghany as far as Olean Point, overcoming, in places, a slope of nearly five feet per mile.

It is well known that the navigation of the Ohio, which, at certain seasons, is scarcely surpassed on living streams, often fails for want of water of sufficient depth to float the boats that can be most advantageously used. It has been proposed, at times, to remedy this defect by leading the water of Lake Erie into the Ohio, and maintaining the navigation by supporting the depth in the channel from that ample source. But it will be perceived by an inspection of the fore-

going table, that the Ohio river at Pittsburg is, at low water, 134 feet *above* the level of Lake Erie; and that the plain of the surface of that lake, extended to the south, will pass 700 feet below the sources of the Alleghany, 395 feet below the town of Franklin, 134 feet below Pittsburg, 55 feet below low water at Wheeling, and would cut the inclined plain of the Ohio between Parkersburg and Marietta, and at a point about 100 miles south of Lake Erie.

It is not at all necessary to refute this proposition as a practical measure; but it is useful to extend the plain of the lake, so as to ascertain what positions it commands in the valley of the Mississippi. It is by carrying such levels over the country that we best illustrate, and best learn to appreciate, the great features of its physical formation.

While it would be impracticable to turn the waters of Lake Erie into the Ohio, nothing would be more feasible than to divert all the head waters of the Alleghany from their course, and precipitate them over the borders into the basin of Lake Erie, down a slope of more than 700 feet in perpendicular height and in a succession of cataracts that would rival Niagara in sublimity.

Such a work might be productive of no useful result, but it could be effected more easily than many undertakings that have been successfully achieved in this country.

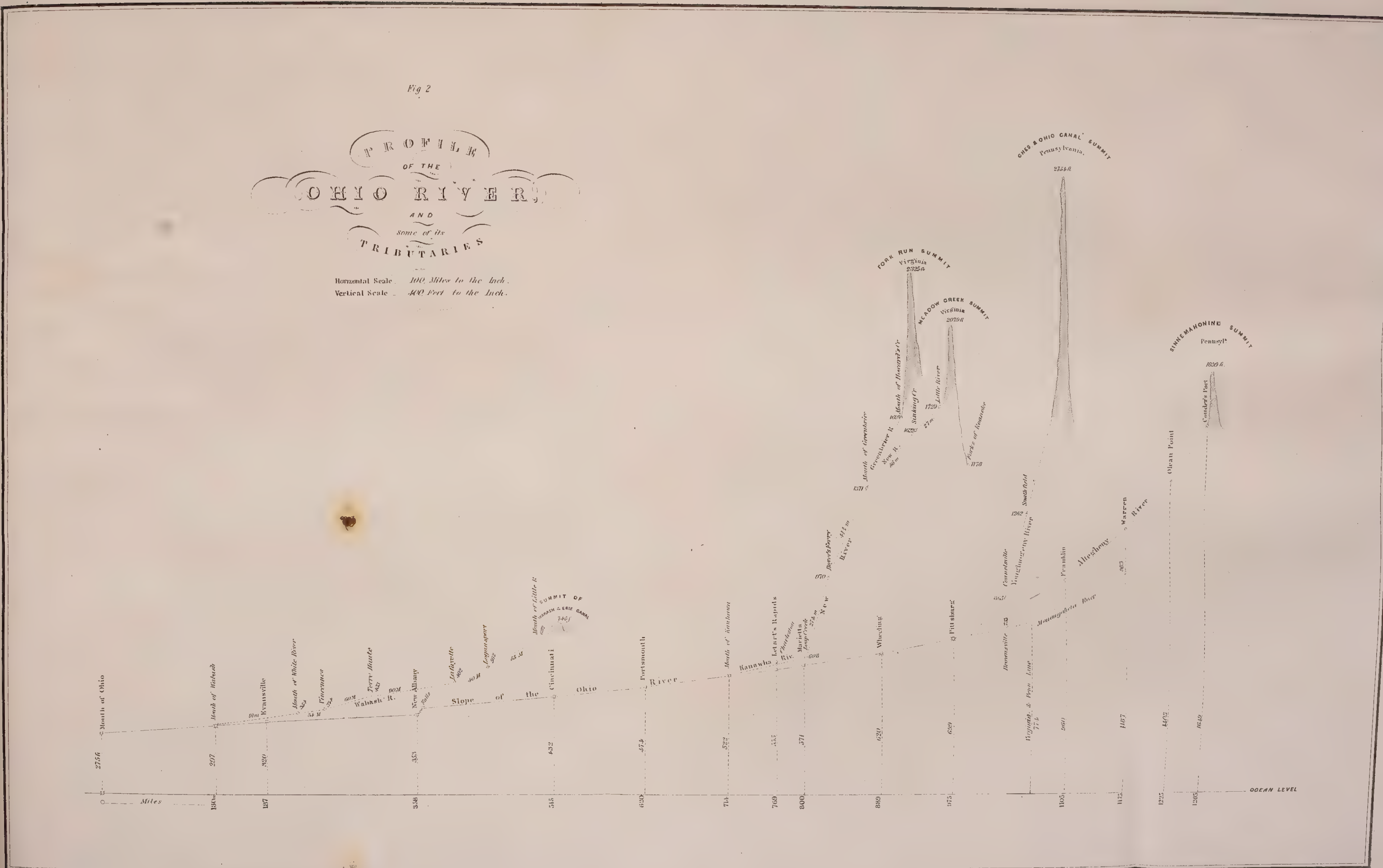
PROFILE OF THE OHIO AND ITS TRIBUTARIES.

The accompanying diagram (Fig. 2) will illustrate the comparative slopes of the Ohio river and its principal tributaries, and serve in some degree to exhibit their relative susceptibility for improvement. The reader will not fail to observe the regularity and symmetry of the curve in profile, formed by the line of descent followed by the Ohio and its chief prolongation, the Alleghany river. From the summit of the Alleghany mountains, where the slender tributaries of this arm of the Mississippi rise opposite to those of the western branch of the Susquehanna, down to the mouth of the Ohio, this great river flows with almost unbroken regularity. Rapid at first where it leaves the mountain sides, it becomes more and more gentle in each hundred miles of its way, until its accumulated waters flow into the Gulf of Mexico.

But the beautiful adjustment of this great artery of commerce can be best appreciated by a comparison of its profile with that of other important rivers, even of its own family.

The great Kanawha is one of the largest tributaries of the Ohio, into which it flows at a point computed to be 714 miles above the confluence of the latter stream with the Mississippi. If we examine this river on the profile, we shall find that it descends more rapidly than the Ohio, even in the first section of 87 miles above its embouchure; but still, for that distance, up to the foot of Loup Creek shoals, possessing the general characteristics of its recipient. For that distance, also, the Great Kanawha is either navigable, or susceptible of being made permanently so by furnishing its channel an abundant supply of water.

Fig 2


PROFILE
OF THE
OHIO RIVER
AND
some of its
TRIBUTARIES
Horizontal Scale 100 Miles to the Inch.
Vertical Scale 400 Feet to the Inch.
CHES & OHIO CANAL SUMMIT
Pennsylvania.
FORK RUN SUMMIT
Virginia
MEADOW CREEK SUMMIT
Virginia
SINNEMAHONING SUMMIT
Pennsylv.
SUMMIT OF WABASH & ERIE CANAL
Mouth of Ohio
Mouth of Wabash
Evansville
Mouth of White River
Vincennes
Terre Haute
Wabash R.
New Albany
Falls
La Fayette
Logansport
Mouth of Little R.
Cincinnati
Slope of the Ohio River
Portsmouth
Mouth of Sandusky
Kanawha Riv.
Letart's Rapids
Charleston
Marietta
New River
Wheeling
Pittsburg
Brownsville
Connelsville
Youghiogheny River
Monongahela River
Franklin
Allegheny River
Warren
Olean Point
Coudersport
Forks of Roanoke
Little River
Mouth of Greenbrier
Greenbrier R.
OCEAN LEVEL
Miles

But in the vicinity of the Falls the character of this river suddenly changes. The profile here mounts up with a quick ascent, which renders idle all expectation of stemming the current. The stream becomes, in fact, a succession of rapids, falling through 362 feet in a space of $27\frac{3}{10}$ miles, which is about twenty-seven times as much as the Ohio falls in the corresponding portion of its course, and more than the descent of Niagara river from Lake Erie to Lake Ontario, which in the same space of about 27 miles passes over the Falls, and descends through rapids almost as sublime as the cataract itself.

A further inspection of the profile of the Kanawha exhibits another fact somewhat remarkable in the descent of this great river.

The acclivity of the Ohio, and that of its tributaries, increases continually as we ascend towards their sources—forming, instead of a plane, a very uniform curve in profile, presenting its *concave* surface upwards. But the outline of the Great Kanawha, from the commencement of the rapids, where it assumes a new character and the name of New river, is the reverse of this arrangement—the slope of that remarkable stream becoming less and less abrupt the nearer we approach its source, up to the very base of the Alleghany mountains, and its profile presenting the form of a curve *convex* to the horizon. The scene of this anomaly in the descent of great streams is at the passage of New river, through the Gauley and other mountains, where stone cliffs of unrivalled height and beauty confine the torrent.

The same peculiarity is observed also, though in a less marked degree, in the profile of the Greenbriar, a tributary of New river; but, with these exceptions, all the great arms of the Ohio obey the law which prevails in the slope of their common recipient, increasing in their acclivity from their mouths to their sources, and often so regularly that the ordinates of increase might be closely represented by an equation of little complexity.

Looking along the profile from east to west, we find the elevation of the dividing ridge between the waters which flow into the Gulf of Mexico, and those which reach the Atlantic through the lakes and the St. Lawrence, highest at the sources of the Alleghany, in the State of New York, and falling away as we pass along the borders of the lakes towards the Mississippi.

The height of the summit which divides the waters of the Genessee, flowing into Lake Ontario, from those of the Alleghany, near the village of Friendship, is 1678 feet above tide;* further west, that which divides Bear lake, at the head of the principal branch of the Connewango, from Lake Erie, is 1320 feet;* still further west, the natural summit between Conneaut lake and the harbor of Erie, in Pennsylvania, is 1095 feet; and proceeding further to the westward we find the surface still more depressed, and the country assuming more and more the appearance of a plane as its level descends.

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* Surveys of Charles Ellet, Jr.

The summit between the Muskingum and Cuyahoga, in Ohio, is but 990 feet above tide; that between the Sandusky and Scioto, also in Ohio, and further west, is 923 feet; the dividing ground between the Wabash and Maumee, in Indiana, is reduced to 745 feet; and, finally, that between the Illinois river and Lake Michigan is but about 610 feet above the level of the sea.

Proceeding from the Ohio to the west, the plane of the country descends towards the Mississippi; where, as before described, it intersects the great plane which forms the bed of the western tributaries of the Father of Rivers. In fact, the great slope from north to south has here, also, a dip from east to west, partaking of the general inclination of the country which prevails from the summit of the Alleghany to the bed of the Mississippi.

This profile must be regarded as a beautiful practical illustration of the accuracy of the spirit level. Many of the elevations which it exhibits have been obtained by lines of survey carried from the Hudson to Lake Erie, and from Lake Erie, through Ohio, Indiana, and Illinois, to different points along the Ohio river; others, by surveys across the mountains of Pennsylvania and Virginia, made by different agents, and requiring the transfer of some fifteen or twenty thousand different observations. Yet these results, continued as the levels have been along lines of five hundred, and in some instances more than a thousand miles in length, are so accurate and consistent, that when the writer had projected in profile the elevation of a point on the Ohio only *sixteen feet* in error, he was enabled to detect the discrepancy, and obtain an authentic result in conformity with other established facts.

It is not practicable to exhibit even all the principal tributaries of the Ohio on the same profile, without producing confusion. They must be compared, therefore, by their respective inclinations and developments.

The Tennessee river is, without question, the first in magnitude and importance, and destined when improved, as it will probably hereafter be, and connected by railroads with the great valley of Virginia, and the seaports of South Carolina, Georgia, and Alabama, to perform a part in the commerce of this Union more important than that of any other stream, save the Ohio, from the Atlantic to the Mississippi.

The mouth of the Tennessee is computed to be 45 miles from that of the Ohio; and its low water level is there about 286 feet above the Atlantic. Its elevation at Chattanooga is 643 feet above tide;† and the average descent of the stream below that place is about seven inches per mile.

The elevation of the Holston, the principal tributary of the Tennessee, is 1914 feet above tide at Seven Miles ford, in Virginia;* and the fall of that portion of the river, between Seven Miles ford and Chattanooga, is about two and a half feet per mile.

The summit which separates the head waters of the Tennessee from those of New river, at Mount Airy, is 2563 feet above the Atlantic.*

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* Surveys of C. Crozet, civil engineer. † Surveys of J. Edgar Thomson, civil engineer.

Cumberland river is the next most important arm of the Ohio, which it enters only 16 miles above the mouth of the Tennessee. The elevation of low water is here about 284 feet above tide.

The surface of the Cumberland, at Nashville, is 388* feet above the Atlantic, or 104 feet above the mouth of the river. The distance by the river, from its entrance into the Ohio, to Nashville, is 240 miles, and the average fall, therefore, 6½ inches per mile—very nearly the same as that of the corresponding portion of its sister stream, the Tennessee, but about twice as great as that of the Ohio below the falls, and that of the Mississippi below the mouth of the Ohio.

The Wabash, next in succession, but perhaps equal in volume to the Cumberland, is the largest of the tributaries of the Ohio which descend along its northern plane. The elevation of low water at the mouth of the Wabash is 297 feet above tide. In the first 91 miles, extending from its confluence with the Ohio to the mouth of White river, the fall is 57 feet, or 7½ inches per mile.†

The foot of the "Grand rapids" is one mile above the mouth of White river. These ripples have an aggregate fall of 10 feet, distributed over a space of eight miles.

The inclination of this great river from point to point is exhibited on the profile. The total descent from the mouth of Little river to the Ohio, a distance computed at 370 miles, is 385 feet, or a small fraction over 12 inches per mile.‡

It is worthy of observation that the rate of descent of the tributaries of the Ohio increases very nearly in proportion to the increase of the slope of the Ohio itself, as we ascend from its mouth to its source. Those rivers which enter below the Falls have gentler currents than those which enter above the Falls; and those which enter above the Falls are more languid than those which come in near its head.

The rate of descent of all these navigable tributaries, near the Ohio, is about twice as great as that of the Ohio itself where joined by the respective tributaries. Thus, the Tennessee, and Cumberland, and Wabash, have each a descent of about 7 inches per mile, while the average slope of the Ohio below the falls is 3 inches per mile. We shall find other examples of this rule as we ascend; but the next river in order is an exception which justifies explanation.

Green river enters on the left border of the Ohio, from the State of Kentucky. The average inclination of this stream, from Bowling Green, on Barren river, a tributary of Green river, to its mouth—a distance of 175 miles—is 4⅛ inches per mile. The actual fall in this distance is 60 feet, and the rate of inclination but one-third greater than that of the lower Ohio.

To comprehend the structure of the country and the cause of this exception,

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* From surveys of J. Edgar Thomson and James H. Grant, civil engineers.

† Letter of Sylvanus Lothrop.

‡ Report of J. L. Williams and Howard Stansbury, civil engineers.

we must bear in mind that there is a continuous slope, approximating to that of a great plane, and extending from the summit of the Alleghany range, continued south, down to the bed of the Ohio. But the prolongation of that dividing range sweeps round through the western end of North Carolina and the northern portions of Georgia and Alabama, until it acquires a nearly due west direction along the southern bend of the Tennessee river. In fact, this great stream follows the course of the mountain range which divides the waters of the Atlantic from those of the Mississippi, and serves to mark its general outline.

Cumberland river then sweeps in an interior circle, concentric to the bend of the Tennessee, and consequently rests lower down upon the great slope which extends from the summit of the dividing range to the vale of the Ohio.

It occupies a lower level than the Tennessee; while Green river follows yet an interior circle, concentric both to the sweep of the Cumberland and that of the Tennessee, and rests nearer to the foot of the same great plane than either of the exterior rivers, and approaches consequently closer in position and level to the bed of the Ohio.

If we proceed from the Ohio in a south or south-eastern direction, crossing the valleys of Green river, the Cumberland, and the Tennessee, successively, we shall be constantly ascending to a higher and higher level; although the route leads over many intermediate elevations and depressions, all resting on the same common slope, which, as before explained, extends from the crest of the dividing ridge to the valley of the Ohio.

For this cause—resting near the foot of the great plane, and running nearly parallel with the course of the Ohio—Green river has a descent less rapid than that of the more elevated beds of the Cumberland and Tennessee, and more rapid than that of the Ohio.

Kentucky river is the next important tributary which we find on ascending towards the north. The distance by the meanders of this stream, from Three Forks to its mouth, is 257½ miles, and the total fall 216 feet, or 10 inches per mile.

The slope of the Ohio between Cincinnati and Louisville is 4½ inches per mile, in accordance with the usual relation between the fall of that stream and the rates of descent of its navigable tributaries.

Licking river, Big Sandy, and the Guyandotte, can hardly be called navigable rivers. They are streams of an inferior class, and obey a rule so general, that it almost amounts to a law, viz., that, under like circumstances, the smaller the tributary of the Ohio the greater is its descent; a rule which holds, with few exceptions, whether the branch enter directly into the principal stream, or reach it indirectly through an affluent of superior magnitude. The largest streams run in the lowest valleys, as if they had made for themselves the deepest channels in the earth.

The Licking river, from West Liberty to the Ohio, a distance of 231 miles, falls 316 feet, or 16½ inches per mile; while Guyandotte river, from Logan's court-house to the Ohio, a distance of 74 miles, falls 142 feet, or 23 inches per

mile. These streams are of about the same class, yet the descent of the former is much the least rapid, as it ought to be, under the assumption that they both descend along the slope of the great plane which reaches from the Alleghany to the Ohio. The Licking crosses the plane obliquely, and descends it gradually; while the Big Sandy and the Guyandotte take a course at right angles to the axis of the mountain ridge, and obtain, therefore, more nearly, the proper inclination of the plane.

The GREAT KANAWHA, the next in succession, is a navigable river, and is correctly represented in the profile. From Loup Creek shoals to the mouth of the river is 89 miles, and the descent 86 feet, or very nearly 12 inches per mile.* The fall of the Ohio, from the mouth of the Kanawha to Cincinnati, is $\frac{13}{100}$ inches per mile—in conformity with the rule.

The LITTLE KANAWHA, from Bulltown to Elizabethtown, $108\frac{1}{2}$ miles, falls 181 feet; and from Elizabethtown to the Ohio, $27\frac{1}{4}$ miles, the fall is 28 feet, or $12\frac{1}{3}$ inches per mile.† The descent of the Ohio below Marietta is $6\frac{17}{100}$ inches per mile.

The SCIOTO is not navigable. The distance from Columbus to Portsmouth is about 100 miles by water, and the fall 302 feet.

The MUSKINGUM, from Zanesville to Marietta, about 60 miles, falls 104 feet.

WHEELING CREEK is a very small tributary, and, like other small tributaries, has a rapid descent. From low water in the Ohio to the mouth of Wolf run, a distance of 17 miles, the fall is 206 feet, or 12 feet per mile.

The ALLEGHANY RIVER, as already shown, descends from Franklin to Pittsburg at the rate of 2 feet per mile; while the Ohio, after receiving its great tributary, flows off with a fall of but little over 1 foot per mile. But the Monongahela, the other great arm, contrary to the rule, and unlike every other tributary, has a descent more gentle even than that of the Ohio itself. The fall of this river, in the 91 miles extending from the Virginia State line to Pittsburg, is 75 feet, or 10 inches per mile. From Weston to the State line, a distance of 107 miles, the fall is 223 feet, or a fraction over 2 feet per mile.

A reference to the map, with constant regard to the fact that there is a continuous though irregular plane, reaching from the Ohio to the summit of the Alleghany mountains, will account for this anomaly.

The course of the Monongahela, from its source to its confluence with the Alleghany, is almost due north; and consequently, in ascending from its mouth to its source, we double upon the course of the Ohio, keeping a direction parallel with that river, and also with the axis of the great dividing ridge. But the Ohio, which marks the foot of the plane, and the summit of the Alleghany, which marks its upper edge, both have a dip to the south; and the Monongahela, running due north, is therefore surmounting the dip while its surface is descending to the Ohio.

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* Surveys of Charles Ellet, Jr.

† Survey of C. Crozet, Esq.

The same considerations apply also to Tygart's Valley, of which the general direction coincides very nearly with that of the Monongahela—both running parallel with the Ohio, but in the opposite direction. But Tygart's valley lies east of the Monongahela, and higher up on the great slope, while it breaks through the ridge of Laurel Hill, and follows the valley lying between that ridge and Cheat mountain. Its fall is therefore greatly increased, and amounts to 150 feet in the first 20 miles above its junction with the Monongahela, or 7½ feet per mile.*

Cheat river, a more important stream than Tygart's Valley, lies still further east, and runs nearly parallel with that stream as well as with the Monongahela, in a valley enclosed between the Cheat and Greenbriar mountains. The fall of this stream is 600 feet in the first 47 miles above its confluence with the Monongahela.*

These mountain ridges and intermediate valleys, and their streams, all run parallel with the crest of the Alleghany, and all rest on the great slope which descends from the summit of that mountain ridge towards the Ohio.

The summit of the Alleghany, at the lowest passes near the sources of the Greenbriar and Cheat rivers, may be stated at -	2,400	ft.	above	tide.
The surface of Cheat river, near the northwestern turnpike, at - - - - - - - - - -	1,375	"	"	"
The surface of Tygart's Valley, in the same latitude, at	1,000	"	"	"
The surface of the Monongahela, in the same parallel, at	910	"	"	"
The surface of the Ohio, above Parkersburg, at - -	570	"	"	"

Descending from the Alleghany to the west, we thus find each stream we cross, in the same parallel, occupying a lower level, until we reach the Ohio, at the foot of the slope. The breadth of this great plane, from east to west, is very uniformly 125 miles, and the total descent in that distance about 1,800 feet, or at the average rate of 14½ feet per mile.

If we now turn to the opposite plane in Ohio, and assume for the level of its origin the summit which separates the waters which flow into Lake Erie by the Sandusky, from those of the Scioto, or 923 feet above tide, and for that of the foot of the slope the level of the Ohio at Portsmouth, we shall again find the distance about 125 miles, but the descent only 450 feet, or $3\frac{6}{10}$ feet per mile.

The average inclination of the great plane, from the east and south, is, therefore, four times as great as that of the great plane from the north.

The Ohio river occupies middle ground in the great valley which it drains, and the waters which it serves to shed are supplied in very nearly equal quantities by its northern and southern slopes.

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* Surveys of Benjamin H. Latrobe, civil engineer.

OF THE DRAINAGE OF THE OHIO.

We are but little aided in the determination of the facts attending the drainage of a country, and the discharge of its rivers, by the previous labor of philosophic writers. The investigations of this subject have been confined, almost exclusively, to the measurements made by engineers of the volume of water which certain inconsiderable streams would furnish during periods of drought, for the use of navigable canals depending on them for supply. No systematic experiments on a large scale, with a view to the determination of the daily and annual discharge of great rivers, and the comparison of that discharge with the annual fall of rain for the climate, so as to obtain the amount consumed by vegitation and evaporation, over wide areas, have ever yet been instituted.

There has, perhaps, never been presented any practical or commercial enterprise, depending on these facts, to elicit an investigation necessarily laborious and costly. The experiments of the writer on the discharge of the Ohio, at Wheeling, will, it is hoped, to some extent, supply this void, and furnish a basis for valuable scientific and economical conclusions.

These experiments were prosecuted during the spring and summer of 1849, for the purpose, mainly, of ascertaining the practicability and cost of supporting the navigation of the Ohio, by supplying the channel with water from reservoirs properly constructed upon its tributaries. The results, it is believed, are not only valuable in establishing this fact, but also of interest as contributions to theoretical and practical science.

The site chosen for these experiments was a space along the Ohio, from the village of Martinsville, above Wheeling, to the Burlington quarries. A portion of the river, 10,063 feet in length, was measured off and divided into four sections. This portion was carefully surveyed and sounded. The width of the surface was determined from point to point by triangulation with a theodolite, and the depth from a series of several hundred soundings.

The observations for the velocity were made on a float properly loaded, and suffered to descend by the force of the current in the thread of the channel. The observer kept alongside of the float, and followed it down in a steamboat, noting the time as it passed the ranges previously established at the several stations on the Ohio and Virginia shores.

The height of the water at the time of each observation was carefully marked, and subsequently determined by the spirit level; and the corresponding depth upon the bar at Wheeling was simultaneously noted, so that all the discharges might be computed with reference to the depth upon that bar. Due precaution was observed to insure accuracy, by so adjusting the float that very little surface should be exposed to the action of the wind—a source of error in such observations exceedingly difficult to obviate. Finally, care was taken to put the float in the thread of the channel, and to endeavor to select suitable weather for each observation.

With all these precautions errors and discrepancies were unavoidable, and it was only by industriously multiplying observations that their effects could be adequately neutralized.

The first experiment was made on the top of the flood of May 8th, 1849, when the water stood $31\frac{25}{100}$ feet upon the bar at Wheeling. The observations were continued frequently as the water fell, so as to obtain experimental results for numerous stages, from a flood of $31\frac{1}{4}$ feet down to a depth of $2\frac{2}{10}$ feet on the bar.

The value of the discharge was determined by multiplying the area of the reduced prism of the channel corresponding with each stage, by the observed velocity—both in feet—and correcting by De Prony's formula for the difference between the surface and the mean velocity of the stream. But to ascertain the volume of water discharged at *every* stage of the river, it was necessary to have the means of deducing from the experimental results, corresponding with given depths on the bar, the volumes which must pass down at every intermediate stage. For this purpose it was essential to construct an empirical formula, which should agree with all the correct results obtained from actual measurement, and thus permit the interpolation of the quantities due to the intermediate depths.

The following equation fulfils that purpose: in which,

d represents the reduced depth of the river, in feet, in the section upon which the velocities were measured; and,

D is the corresponding discharge per hour, in cubic feet, when the reduced depth is d. Then,

$$1{,}083{,}000\, d^2 - 10{,}000\, d^3 = D.$$

or the number of cubic feet hourly discharged when the depth is d.

This formula agrees satisfactorily with the observed discharges for all the reduced depths at which observations were taken; and within those limits may be used in preference to the observations themselves, and to interpolate for heights intermediate between the observations. But, having a maximum value, it would not be admissible to extend its application very far beyond the limits for which it was constructed There is, in fact, no maximum to the discharge, while the value of d increases.

The following table exhibits, side by side, the quantities discharged, as determined by this formula, and those calculated for the same depths from the observations.

The first column represents the depth on the bar at Wheeling; the second, the corresponding reduced depth at the place of observation, or the value of d; the third, the observed velocity of the float; the fourth, the calculated discharge, or the value of D; the fifth is the observed, or measured discharge.

The average width of the river in the section where the velocities were determined was 1,066 feet, when the depth on the bar was $5\frac{38}{100}$ feet, and of course varied irregularly with the depth.

TABLE III.

OF THE CALCULATED AND OBSERVED DISCHARGES OF THE OHIO RIVER AT WHEELING.

No. of observations.	Depth of water on the bar at Wheeling.	Reduced depth at place of observation, or value of *d*.	Velocity of central current in feet per hour.	Discharge in cubic feet per hour, ascertained by observation.	Discharge in cubic feet per hour, calculated by formula.
1	2.20	3.43	3,594	10,158,000	12,338,000
2	2.72	3.85	3,552	11,268,000*	15,487,000
3	3.55	4.60	5,890	22,650,000†	21,887,000
4	3.71	4.75	5,030	20,100,000‡	23,300,000
5	4.20	5.18	5,095	22,270,000§	27,580,000
6	4.89	5.85	6,708	33,300,000	35,000,000
7	5.38	6.31	6,423	34,560,000	40,495,000
8	5.55	6.48	7,564	41,600,000	42,640,000
9	5.72	6.65	8,356	47,300,000	44,820,000
10	6.72	7.65	9,196	60,000,000	58,723,000
11	7.92	8.82	11,028	83,000,000	77,140,000
12	9.66	10.51	12,804	118,400,000	108,100,000
13	11.04	11.84	14,946	156,400,000	138,700,000
14	11.31	12.10	14,637	154,000,000	140,000,000
15	15.06	15.74	16,500	226,000,000	229,000,000
16	20.76	21.22	20,126	378,000,000	391,000,000
17	25.16	25.45	23,222	530,000,000	535,000,000
18	27.92	28.16	24,000	611,000,000	632,300,000
19	31.25	31.41	24,644	736,000,000	758,300,000

* Head wind. † Wind down stream. ‡ Head wind. § Head wind.

It will be seen that there are several irregularities in this table. In two instances the velocities exhibit a slight increase, although the depth, in the channel were diminished. In some instances the float left the thread of the stream, and was consequently retarded.

In the lower velocities the irregularities are very considerable, and were caused altogether by the wind. It was almost impossible to obtain observations, when the water was very low, which were not disturbed by this cause. The experiments, in this state of the river, consumed from two to three hours, and the exposure of the float during all that time, to the slightest breeze, affected the result materially. This could not be obviated by depressing it beneath the surface of the water, for the surface of the water itself was also retarded. These discrepancies are inseparable from the subject. Yet we shall find, by summing up all the computed and all the observed quantities, that in the aggregate they agree almost precisely. The formula represents the mean of

many observations, and is therefore more to be relied on for every stage of the water, than any single experiment that can possibly be made expressly for a given stage.

The objects of the research required that we should possess a convenient means of determining the actual discharge of the Ohio river in every condition of its waters, and for every day during a series of years.

The following table has been constructed for this purpose, from the foregoing formula, modified to express the diurnal instead of the hourly discharge. The table exhibits only the volume due to each foot in height, and of course will require interpolations for the fractions of feet. It is extended from common low water up to a flood of 36 feet—the highest, save one, which has been known in the Ohio, at Wheeling, for the space of a quarter of a century.

The scientific reader will recognise the utter impracticability of framing an empirical equation, which shall express minutely the volume of water flowing in a channel confined by such rude and irregular surfaces as the bed and borders of a great river. The writer, not wishing to affect a precision incompatible with the nature of the problem, has neglected the small decimals in carrying out the calculations for the construction of this table, taking care merely to preserve accuracy to the third place, so as to avoid any error equal to one per cent. of the discharge indicated by the formula for any given stage of the river.

The following equation, in which d is put for the reduced depth in feet, and D for the diurnal discharge of the river in cubic feet, will represent the volume of water flowing down the Ohio, at Wheeling, in a period of 24 hours, with as much precision as can be desired for any practical purpose.

$$26{,}000{,}000\, d^2 - 240{,}000\, d^3 = D.$$

The equation, in this form, is more convenient for application than the preceding.

In Table IV, the figures in the third column show the number of cubic feet of water flowing past Wheeling, for the depths on the bar, which are given in the first column.

TABLE IV.

SHOWING THE VOLUME OF WATER DISCHARGED BY THE OHIO IN 24 HOURS AT GIVEN DEPTHS ON WHEELING BAR.

Depth in feet on Wheeling bar.	Reduced depth where gauged.	Discharge in 24 hours in cubic feet.
1.00	2.00	102,000,000
2.00	3.00	228,000,000
3.00	3.98	400,000,000
4.00	4.97	620,000,000
5.00	5.96	864,000,000
6.00	6.95	1,164,000,000
7.00	7.94	1,511,000,000
8.00	8.92	1,890,000,000
9.00	9.90	2,314,000,000
10.00	10.86	2,754,000,000
11.00	11.82	3,225,000,000
12.00	12.78	3,726,000,000
13.00	13.74	4,279,000,000
14.00	14.71	4,854,000,000
15.00	15.68	5,480,000,000
16.00	16.64	6,103,000,000
17.00	17.60	6,744,000,000
18.00	18.55	7,413,000,000
19.00	19.50	8,100,000,000
20.00	20.46	8,819,000,000
21.00	21.40	9,556,000,000
22.00	22.38	10,333,000,000
23.00	23.35	11,120,000,000
24.00	24.32	11,922,000,000
25.00	25.30	12,752,000,000
26.00	26.28	13,640,000,000
27.00	27.26	14,444,000,000
28.00	28.24	15,322,000,000
29.00	29.22	16,228,000,000
30.00	30.20	17,088,000,000
31.00	31.16	17,972,000,000
32.00	32.10	18,760,000,000
33.00	33.00	19,700,000,000
34.00	34.00	20,624,000,000
35.00	35.00	21,600,000,000
36.00	36.00	22,500,000,000

The foregoing table, with interpolations for the fractions of feet, supplies a convenient means of determining the daily discharge of the Ohio at Wheeling for any given depth upon the bar at that place.

But to make practical applications of the information which it contains, we need an authentic account of the daily height of water upon the bar, to which the table refers, for a series of years. And this has, fortunately, been procured.

By reference to the books of the wharf master of the city, the files of the "Times" newspaper and the minutes of the Reporter, the writer has succeeded in obtaining an almost unbroken record of the daily depth upon the Wheeling bar, from the year 1838 down to 1848, including both.

The heights of the water were measured, up to 16 feet, on a monument established by the city authorities, under the inspection and by the levels of Captain (now Major) Sanders, of the U. S. Corps of Engineers. The height of the flood of 1832, the highest ever known, has been repeatedly and carefully levelled, as have also the marks of numerous other intermediate freshets. These heights have been compared with the record, and the agreement has been such as to impart entire confidence in the care with which the observations have been noted.

These records will be found in the succeeding pages, and will furnish, it is hoped, the basis of conclusions interesting to science as well as to the commerce of the country.

In the following tables, the height of the water on the Wheeling bar is shown for each day of the year to which the respective tables apply. At the foot of the column which exhibits the record of the daily height for each month, is shown the total discharge in cubic feet for the whole of that month. The figures below the monthly discharge, in the same column, represent the height which might have been maintained throughout the month, if the water which passed down the river in that time had been discharged uniformly. These tables further exhibit the total annual discharge in cubic feet, and the constant height which might have been maintained upon the Wheeling bar throughout the year, if that discharge had been regulated by art and made uniform.

This important and interesting inquiry is believed never to have been made for any river with equal care and accuracy; if, indeed, any authentic experiments of the kind have ever before been instituted at all.

The primary object of the writer was, as already stated, to determine the volume of water discharged by the Ohio at given stages, with a view to decide on the practicability and cost of supplying the deficiency, in times of drought, from stores reserved in artificial lakes from the superabundance which is wasted during floods, so as to maintain the navigation effectually throughout the year. Yet, in the progress of the investigation, other important and equally interesting problems very naturally arose for solution. It was desirable, also, to measure the discharge in times of freshets, so as to be able to judge whether, in the onward strides of science and art, we had not already reached a point where it

was possible to curb, and render harmless, THE FLOODS which now annually sweep through the western valleys.

On seeking to find how much water would be needed to maintain the navigation at any given height, it became important, further, to determine the *maximum height* at which it could be permanently held—a question of vast importance to the mind that views the interior navigation of this country but as a continuation of that of the ocean; and is directed forward to the day when every city upon the banks of the Mississippi, Missouri, and a portion of the Ohio, is to become a port of foreign entry, accessible to ocean steamers; when the forests of the interior are to furnish the timber, the mines of the interior the iron and coal, the workshops of the interior the machinery of the vessels, and the fertile plains of the Mississippi valley the freight, which is to be shipped from the seaports of the interior to the markets of the world.

The commercial position and advantages of this wonderful valley are sublime; and its physical capabilities deserve a far more perfect investigation than can be expected of private zeal. Still, the purposes of the writer required the solution of this interesting problem; and he was therefore compelled to compute, day by day, the discharge of the river for the whole year; and to render the results more worthy of confidence, for a continuous period of six years.

The same train of inquiry necessarily led to the determination of the annual drainage, and its comparison with the annual fall of rain over the wide district covered by the tributaries of the Ohio; and, as a consequence, the annual consumption of water in the processes of vegetation and evaporation.

These results are briefly stated in this paper; and being deduced from an area of nearly 25,000 square miles, and for a series of years, they possess an interest much greater than could attach to any local or more limited inquiry.

It will be found that the expectations which led to the laborious undertaking have been fully confirmed; that the steamboat navigation of the Ohio may be permanently maintained for a very trifling outlay; and that the power of the floods also may be greatly reduced by an incidental application of the reservoirs which will support the navigation. The results show that it is quite practicable to maintain an uniform height of water in this river, and that that height may be ultimately raised, at Wheeling, to *nine feet*. (See note A.) But these more remote applications are not discussed here. The present inquiry is limited to things immediate—valuable to science, or useful to the public welfare.

TABLE V.

RECORD OF THE DEPTH OF WATER ON THE WHEELING BAR FOR THE YEAR 1848.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	13	10	$8\frac{1}{2}$	17	$4\frac{7}{12}$	11	$4\frac{1}{2}$	8	$3\frac{5}{6}$	$2\frac{1}{6}$	$4\frac{1}{2}$	7
2	21	$9\frac{1}{4}$	8	$16\frac{1}{2}$	$4\frac{1}{2}$	$10\frac{3}{4}$	$4\frac{1}{2}$	8	$3\frac{2}{3}$	$2\frac{1}{4}$	$4\frac{2}{3}$	7
3	25	$9\frac{1}{2}$	$7\frac{1}{4}$	$16\frac{1}{2}$	$5\frac{1}{2}$	10	$4\frac{1}{3}$	7	$3\frac{1}{4}$	$2\frac{1}{6}$	$5\frac{1}{2}$	7
4	25	9	$6\frac{3}{4}$	14	$5\frac{3}{4}$	7	$5\frac{1}{2}$	$7\frac{1}{4}$	$3\frac{1}{2}$	$2\frac{1}{2}$	$4\frac{5}{6}$	$7\frac{1}{2}$
5	26	$8\frac{1}{2}$	$6\frac{1}{2}$	$10\frac{1}{2}$	7	7	9	7	$3\frac{1}{3}$	$2\frac{2}{3}$	$4\frac{1}{2}$	8
6	24	$7\frac{2}{3}$	5	10	$8\frac{1}{4}$	$5\frac{3}{4}$	9	6	$3\frac{1}{3}$	4	6	11
7	18	$8\frac{1}{4}$	5	$9\frac{1}{2}$	11	$5\frac{3}{4}$	10	6	$3\frac{1}{6}$	$4\frac{1}{2}$	5	11
8	15	$7\frac{1}{4}$	5	9	17	$6\frac{1}{2}$	11	$5\frac{3}{4}$	3	4	$4\frac{3}{4}$	11
9	13	$7\frac{1}{4}$	$5\frac{3}{4}$	$9\frac{1}{2}$	17	6	$10\frac{1}{2}$	$5\frac{1}{2}$	$2\frac{1}{12}$	4	$7\frac{1}{4}$	9
10	13	$6\frac{1}{2}$	6	$8\frac{3}{4}$	14	$5\frac{1}{2}$	$10\frac{1}{2}$	5	$2\frac{1}{4}$	$3\frac{3}{4}$	$8\frac{1}{2}$	11
11	10	$6\frac{1}{4}$	$6\frac{1}{4}$	$8\frac{1}{6}$	13	5	$9\frac{1}{2}$	$4\frac{1}{3}$	$2\frac{5}{6}$	$3\frac{3}{4}$	8	14
12	$8\frac{1}{2}$	6	8	8	12	$4\frac{1}{2}$	$8\frac{3}{4}$	$4\frac{1}{4}$	$2\frac{1}{2}$	$3\frac{1}{2}$	7	17
13	8	$5\frac{5}{6}$	8	$7\frac{1}{2}$	13	$4\frac{1}{2}$	$7\frac{1}{2}$	4	$2\frac{1}{2}$	$3\frac{1}{4}$	$6\frac{2}{3}$	19
14	$7\frac{1}{2}$	$5\frac{3}{4}$	11	$7\frac{1}{4}$	$13\frac{1}{2}$	$4\frac{1}{6}$	6	4	$2\frac{1}{3}$	3	7	19
15	$7\frac{1}{4}$	$5\frac{1}{4}$	$11\frac{1}{2}$	7	14	$3\frac{5}{6}$	6	$3\frac{2}{3}$	$2\frac{1}{6}$	$2\frac{3}{4}$	8	17
16	$8\frac{1}{2}$	5	11	$6\frac{1}{2}$	12	$3\frac{3}{4}$	$5\frac{3}{4}$	$3\frac{1}{2}$	$2\frac{1}{12}$	$2\frac{1}{2}$	10	11
17	$8\frac{1}{2}$	4	9	$6\frac{1}{2}$	11	$3\frac{7}{12}$	$5\frac{3}{4}$	$3\frac{5}{12}$	$1\frac{5}{6}$	$2\frac{7}{12}$	7	13
18	16	$4\frac{3}{4}$	$8\frac{1}{2}$	$6\frac{1}{4}$	$10\frac{3}{4}$	$3\frac{1}{2}$	$5\frac{2}{3}$	$3\frac{1}{3}$	$1\frac{1}{12}$	$2\frac{7}{12}$	8	$10\frac{1}{2}$
19	16	$5\frac{1}{4}$	$7\frac{3}{4}$	6	12	$3\frac{1}{2}$	$5\frac{1}{2}$	$3\frac{1}{16}$	$2\frac{1}{12}$	$2\frac{7}{12}$	$8\frac{1}{2}$	$10\frac{1}{2}$
20	13	7	$7\frac{3}{4}$	6	$14\frac{1}{2}$	$3\frac{1}{2}$	$4\frac{1}{2}$	$3\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{7}{12}$	$8\frac{1}{2}$	9
21	12	7	9	$5\frac{3}{4}$	14	$3\frac{1}{3}$	4	$3\frac{1}{2}$	$2\frac{5}{6}$	$2\frac{1}{2}$	8	$8\frac{3}{4}$
22	10	8	15	$5\frac{1}{2}$	$13\frac{1}{2}$	$3\frac{5}{6}$	4	$3\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{7}{12}$	7	$9\frac{1}{2}$
23	9	14	18	$5\frac{5}{6}$	12	$4\frac{1}{2}$	$4\frac{1}{4}$	$3\frac{3}{4}$	$2\frac{1}{3}$	$2\frac{7}{12}$	$6\frac{1}{4}$	18
24	$8\frac{1}{2}$	$14\frac{1}{2}$	$17\frac{1}{2}$	$5\frac{3}{4}$	12	$5\frac{1}{2}$	$5\frac{1}{2}$	$6\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{3}{4}$	$5\frac{3}{4}$	28
25	8	16	17	$5\frac{3}{4}$	15	$5\frac{1}{2}$	$4\frac{1}{4}$	$5\frac{1}{2}$	$2\frac{3}{4}$	$2\frac{5}{6}$	$5\frac{3}{4}$	28
26	$7\frac{3}{4}$	$14\frac{1}{2}$	16	$5\frac{1}{2}$	14	$5\frac{3}{4}$	$4\frac{1}{2}$	$5\frac{1}{4}$	$2\frac{1}{3}$	$3\frac{1}{2}$	$5\frac{5}{12}$	24
27	$7\frac{1}{4}$	$12\frac{1}{2}$	16	$5\frac{5}{12}$	$10\frac{1}{2}$	5	$7\frac{1}{2}$	5	$2\frac{2}{3}$	$3\frac{1}{2}$	$7\frac{3}{4}$	23
28	7	$12\frac{1}{2}$	14	5	10	$4\frac{5}{6}$	7	5	$2\frac{5}{6}$	$3\frac{5}{12}$	$7\frac{3}{4}$	22
29	$7\frac{1}{2}$	$9\frac{1}{2}$	16	$4\frac{5}{6}$	10	$4\frac{5}{6}$	$6\frac{1}{4}$	4	$2\frac{1}{3}$	$4\frac{5}{12}$	9	16
30	$9\frac{1}{2}$	–	18	$4\frac{7}{12}$	10	$4\frac{1}{2}$	$5\frac{1}{2}$	5	$2\frac{1}{4}$	6	$8\frac{1}{2}$	14
31	$8\frac{1}{2}$	–	$17\frac{1}{2}$	–	$10\frac{1}{2}$	–	$5\frac{1}{2}$	4	–	6	–	14
Discharge in each month.	141,076,000,000	65,914,000,000	102,781,000,000	64,468,000,000	109,663,000,000	31,085,000,000	44,266,000,000	27,143,000,000	10,587,000,000	15,173,000,000	44,923,000,000	165,640,000,000
Eq. mo. heights.	$13\frac{1}{2}$	$8\frac{9}{10}$	$11\frac{18}{100}$	$8\frac{62}{100}$	$11\frac{63}{100}$	$5\frac{6}{10}$	$6\frac{77}{100}$	$5\frac{4}{10}$	$2\frac{74}{100}$	$3\frac{43}{100}$	$6\frac{96}{100}$	$14\frac{78}{100}$

Annual discharge, 822,719,000,000 ; equiv. uniform height, 8.85.

As already explained, the foregoing table exhibits the daily height of the water on the bar at Wheeling for the year 1848; and at the foot of each column is shown the number of cubic feet discharged by the Ohio during the month to which the depths in that column apply, and also the uniform height at which the water could have been maintained by the discharge of the month, if that discharge had been uniform.

On summing up these result, we find that the total volume discharged by the Ohio at Wheeling, for the year 1848, was—

822,719,000,000 cubic feet.

Dividing this quantity by 366, we obtain for the average daily discharge for that year—

2,248,000,000 cubic feet.

If we now refer to Table IV, or to the formula from which that table was constructed, we shall find that the daily average quantity discharged during the year was just sufficient to have maintained the water upon the Wheeling bar at an uniform height of $8\frac{85}{100}$ feet.

The area drained by the Ohio and its tributaries, above Wheeling, is estimated in this paper at 24,337 square miles; or,

678,476,000,000 square feet.

It follows, then, if we divide the above annual discharge in cubic feet by the area drained, that the volume of water which flowed down the Ohio, at Wheeling, in 1848, was just sufficient, if spread over this space, to have raised the surface $1\frac{213}{1000}$ feet; or,

$14\frac{556}{1000}$ inches.

Such is the value of the total drainage of the region watered by the upper Ohio for that year. The greatest monthly value was in December, when it amounted to—

$2\frac{93}{100}$ inches;

and the least monthly result was in September, when it amounted only to—

$\frac{187}{1000}$ of an inch.

There is one other fact exhibited in Table V, which has a most important practical application, and may be properly noticed in this connexion.

It appears by the record that the water was below five feet in February, and also in April and May; that it was down nearly to three feet in June, as low as four feet in July, at three and a half feet in August, below two feet in September, two feet and two inches in October, and again at four and a half feet in November; and yet the calculation shows that the discharge was sufficient, in each of those months, excepting only September and October, to have maintained the navigation at five and a half feet, or more, throughout the month.

The volume of water which the river actually furnished in each month (with those two exceptions) was sufficient to have maintained a depth of $5\frac{1}{2}$ feet on the Wheeling bar, without reserving the excess of any previous month. All that was needed to obtain and secure a minimum depth of $5\frac{1}{2}$ feet for navigation, was *to regulate the actual discharge of each month.*

In September the water was down below two feet on the bar; yet the discharge for that month alone would have maintained a navigation for boats of 2 feet 9 inches draught.

In October the water was twice down to 2 feet 2 inches, and several times below $2\frac{1}{2}$ feet; yet the supply for that month, without any reserve for previous excess, would have maintained a uniform draught of 3 feet 5 inches.

The total discharge for September was - -	10,587,000,000 cubic feet.
The total discharge for October - - - -	15,173,000,000 " "
The total actual discharge for September and October, together, amounted to - - -	25,760,000,000 " "

To have maintained a navigation during these two months for boats drawing 5 feet would have required a daily supply, according to Table IV, of 864,000,000 cubic feet; or a total, for the whole period of 61 days, of 52,704,000,000 cubic feet.

The difference between this—the quantity which would be discharged with five feet on the bar—and the quantity which was actually discharged, is then 26,944,000,000 cubic feet.

This is the volume of water which it would have been necessary to provide that year to have kept the river at a minimum height of 5 feet.

The volume here deduced from actual measurement on an extensive scale, would very nearly fill a reservoir 107 feet deep, and covering an area of three miles square.

It would require only three dams, no larger than several of those in use on the Lehigh, to be constructed across the Alleghany, to supply the whole of this volume of water. Three such dams can be built in the usual manner, and furnished with locks for the accommodation of the trade above, as is common on other great rivers, and be completely provided with the means of drawing off the water, as it is needed, for about $450,000.

TABLE VI.

RECORD OF THE DAILY HEIGHT ON THE WHEELING BAR FOR THE YEAR 1847.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	17	9	$14\frac{1}{2}$	$8\frac{3}{4}$	$6\frac{3}{4}$	$6\frac{1}{3}$	$5\frac{1}{4}$	$6\frac{1}{2}$	$2\frac{3}{4}$	$9\frac{1}{2}$	14	12
2	24	10	15	12	$6\frac{3}{4}$	6	$5\frac{1}{4}$	$6\frac{1}{2}$	$2\frac{2}{3}$	$8\frac{1}{2}$	$9\frac{1}{2}$	16
3	28	11	12	11	$6\frac{2}{3}$	6	$4\frac{5}{6}$	$5\frac{3}{4}$	$2\frac{1}{2}$	7	8	16
4	23	9	11	11	$6\frac{1}{4}$	$8\frac{1}{2}$	$4\frac{1}{4}$	$5\frac{1}{4}$	$2\frac{2}{3}$	7	$7\frac{3}{4}$	16
5	23	$11\frac{1}{2}$	10	10	$6\frac{1}{2}$	9	$4\frac{1}{6}$	$4\frac{5}{6}$	$2\frac{1}{2}$	7	$7\frac{1}{4}$	18
6	22	15	$9\frac{1}{2}$	$9\frac{1}{2}$	$6\frac{1}{4}$	$10\frac{3}{4}$	4	$4\frac{1}{2}$	$2\frac{1}{2}$	$6\frac{1}{2}$	7	16
7	22	14	9	9	6	9	$3\frac{3}{4}$	$4\frac{1}{4}$	$2\frac{1}{4}$	$6\frac{1}{3}$	$6\frac{1}{6}$	13
8	21	11	9	11	$6\frac{1}{2}$	$8\frac{1}{6}$	$3\frac{2}{3}$	$3\frac{5}{6}$	$2\frac{1}{4}$	6	$6\frac{1}{4}$	$11\frac{1}{2}$
9	19	10	19	14	$5\frac{5}{6}$	$8\frac{3}{4}$	$3\frac{1}{2}$	$3\frac{2}{3}$	$2\frac{1}{4}$	$6\frac{1}{2}$	6	10
10	14	$10\frac{1}{2}$	$22\frac{1}{4}$	15	6	7	$3\frac{1}{3}$	$3\frac{2}{3}$	4	21	$5\frac{3}{4}$	10
11	12	$11\frac{1}{2}$	27	16	$6\frac{3}{4}$	$6\frac{1}{2}$	$3\frac{1}{3}$	$3\frac{2}{3}$	$2\frac{5}{6}$	19	$6\frac{1}{2}$	18
12	$9\frac{1}{2}$	11	26	16	$6\frac{1}{2}$	$6\frac{1}{4}$	$3\frac{1}{3}$	$4\frac{1}{2}$	$2\frac{5}{6}$	19	$7\frac{1}{2}$	23
13	9	10	21	16	$5\frac{1}{4}$	$5\frac{1}{4}$	$3\frac{1}{3}$	$4\frac{1}{4}$	$2\frac{5}{6}$	13	$8\frac{3}{4}$	28
14	$8\frac{1}{2}$	9	14	$12\frac{1}{2}$	$6\frac{1}{8}$	$6\frac{1}{4}$	$3\frac{1}{4}$	$4\frac{1}{4}$	$3\frac{5}{6}$	13	$8\frac{1}{2}$	38
15	$7\frac{1}{2}$	$8\frac{1}{2}$	13	$11\frac{1}{2}$	5	$5\frac{2}{3}$	3	$4\frac{1}{3}$	$3\frac{5}{6}$	13	8	$38\frac{1}{2}$*
16	$7\frac{1}{2}$	8	12	$9\frac{1}{2}$	$5\frac{1}{6}$	$5\frac{1}{2}$	$3\frac{7}{12}$	$4\frac{1}{3}$	$3\frac{1}{2}$	17	$8\frac{1}{2}$	35
17	11	$7\frac{1}{2}$	10	$9\frac{1}{2}$	$4\frac{3}{4}$	$5\frac{1}{4}$	$3\frac{7}{12}$	$5\frac{1}{2}$	$3\frac{1}{6}$	17	9	30
18	15	$9\frac{1}{2}$	$8\frac{1}{2}$	8	$4\frac{2}{3}$	$5\frac{3}{4}$	$3\frac{1}{2}$	$5\frac{1}{2}$	$2\frac{5}{6}$	$16\frac{1}{2}$	10	25
19	16	$13\frac{1}{2}$	8	8	$4\frac{1}{2}$	$5\frac{1}{4}$	3	4	$2\frac{5}{6}$	12	11	21
20	15	$17\frac{1}{2}$	10	$7\frac{3}{4}$	$4\frac{1}{4}$	$8\frac{1}{3}$	3	$4\frac{3}{4}$	3	$9\frac{1}{2}$	9	21
21	$11\frac{1}{2}$	22	8	7	$4\frac{1}{8}$	8	$2\frac{5}{6}$	$4\frac{5}{6}$	3	$8\frac{3}{4}$	$9\frac{1}{2}$	13
22	11	27	14	$6\frac{1}{2}$	4	$8\frac{1}{2}$	3	$3\frac{2}{3}$	$3\frac{5}{6}$	$7\frac{3}{4}$	$8\frac{1}{2}$	$11\frac{1}{2}$
23	$10\frac{1}{2}$	$24\frac{1}{2}$	17	6	$3\frac{2}{3}$	9	$3\frac{1}{4}$	$3\frac{2}{3}$	$3\frac{2}{3}$	7	$9\frac{1}{2}$	$10\frac{1}{2}$
24	$8\frac{3}{4}$	22	17	$6\frac{1}{4}$	$3\frac{2}{3}$	$8\frac{3}{4}$	4	$3\frac{7}{12}$	$3\frac{1}{2}$	7	$8\frac{3}{4}$	$9\frac{1}{2}$
25	$8\frac{1}{2}$	21	16	$8\frac{1}{3}$	$3\frac{1}{2}$	$7\frac{3}{4}$	$4\frac{3}{4}$	$3\frac{1}{2}$	4	7	12	$8\frac{3}{4}$
26	7	17	15	$8\frac{1}{4}$	4	8	$4\frac{3}{4}$	$3\frac{5}{12}$	$5\frac{1}{2}$	10	21	9
27	$7\frac{1}{6}$	14	12	$8\frac{1}{4}$	$7\frac{7}{12}$	$6\frac{1}{3}$	$5\frac{2}{3}$	$3\frac{1}{3}$	$6\frac{3}{4}$	16	32	$7\frac{3}{4}$
28	$8\frac{1}{6}$	16	10	$8\frac{1}{4}$	$7\frac{1}{2}$	6	$7\frac{1}{2}$	$3\frac{1}{4}$	$6\frac{3}{4}$	17	27	$7\frac{3}{4}$
29	$7\frac{3}{4}$	–	$9\frac{1}{2}$	$7\frac{1}{4}$	7	$5\frac{3}{4}$	13	$3\frac{1}{2}$	$8\frac{1}{2}$	18	22	$7\frac{1}{2}$
30	$8\frac{3}{4}$	–	$9\frac{1}{4}$	7	$6\frac{1}{2}$	$5\frac{3}{4}$	11	3	9	17	12	$6\frac{1}{2}$
31	9	–	9	–	$6\frac{1}{2}$	–	$8\frac{3}{4}$	$2\frac{5}{6}$	–	$15\frac{1}{2}$	–	$8\frac{1}{2}$
Discharge in each month, in cubic feet.	159,047,000,000	139,657,000,000	152,109,000,000	85,337,000,000	33,548,000,000	46,689,000,000	27,248,000,000	21,706,000,000	18,678,000,000	122,931,000,000	110,605,000,000	224,703,000,000
Eq. mo. heights.	$14\frac{45}{100}$	$14\frac{22}{100}$	$14\frac{9}{100}$	$10\frac{20}{100}$	$5\frac{74}{100}$	$7\frac{13}{100}$	$5\frac{54}{100}$	$4\frac{33}{100}$	4	$12\frac{45}{100}$	$11\frac{93}{100}$	$17\frac{76}{100}$

Annual discharge, 1,142,258,000,000 cubic feet; equiv. uniform depth, $10\frac{8}{10}$.

* According to other authority, this flood, and that of February, 1840, should be 36 feet.

By referring to the foregoing record of heights for the year 1847, we obtain the following valuable results:

The total drainage of the Ohio at Wheeling was—

1,142,258,000,000 cubic feet;

and the average daily discharge—

3,129,000,000 cubic feet.

From which it results, by applying the formula, or Table IV, that if the water had all been shed uniformly, so as to maintain the river throughout the year at a constant height, that height would have been $10\frac{8}{10}$ feet upon the Wheeling bar, or within a small fraction of two feet more than in the year 1848.

If we again divide the area drained into the volume discharged, we obtain for the year 1847 a total drainage equal to $1\frac{684}{1000}$ feet; or,

$20\frac{1}{5}$ inches.

The greatest drainage of this year, also, was in the month of December, when it amounted to—

$3\frac{98}{100}$ inches;

and the least monthly drainage again in September, when it amounted to—

$\frac{33}{100}$ of an inch.

It appears, therefore, that the total drainage of the upper Ohio, in 1847, was about 38 per cent. greater than that of 1848; that the greatest monthly drainage of that year was 35 per cent. greater than that of 1848; and the least monthly drainage nearly 100 per cent. greater than the least monthly drainage of 1848.

On comparing the two tables further, we find that the irregularities were very great. In the month of October, 1847, the river discharged more than *eight times* as much water as in the same month of 1848; while the discharge for a single day—the 15th of December, 1847—was as great as that of sixty days in September and October, 1848.

The computation of the daily and monthly drainage of this year also leads to some very valuable practical observations.

In 1848 the height of the water at Wheeling frequently oscillated between 22 and 27 inches through September and October; although in those two months the actual discharge was sufficient to have maintained the navigation constantly at a depth of $3\frac{25}{100}$ feet—a depth sufficient for the movement of a respectable class of freight boats, and consequently to protect the public against prohibitory or extravagant charges. All that was that year (1848) necessary to prevent this irregularity, was two small dams—one on each river above Pittsburg—to act as *regulators of the natural flow*. Two dams of very moderate height, and two men to control them—dams which would also have furnished a sufficient additional supply of water to raise the depth, even in those

months, to 4 feet—could be built upon those rivers for an outlay of not more than $150,000 each.

In 1847 the depth was sometimes as low as $2\frac{1}{4}$ feet at Wheeling; yet it will be seen, by reference to the table for that year, that in each month the natural flow was sufficient, if it had been well regulated, to have maintained an uniform depth of at least four feet throughout the month.

In the month of July (1847) the depth on the Wheeling bar was frequently but 3 feet, and once less than 3 feet; yet, the discharge for that very month was sufficient to have maintained an uniform depth of $5\frac{1}{2}$ feet.

In August the depth was also reduced below 3 feet; but the average flow was sufficient to have maintained it throughout the month at $4\frac{1}{3}$ feet.

In September the water fell to $2\frac{1}{4}$ feet, and varied from that to 4 and 5 feet. The actual flow, as shown by the table—the results of which are obtained in all cases from actual calculation for each day—would have maintained the height constantly, the whole month, at 4 feet.

Now, all that was needed to protect the navigation throughout 1847 was two small dams—one on each of the great branches of the Ohio—to create reservoirs of moderate capacity, to be vented as the river fell on the occurrence of a drought; and to catch the surplus water furnished by the small freshets which occurred during the summer, and discharge it again, as needed, into the stream below.

To supply a large volume of water, with a view to the maintenance of a depth sufficient for the proper movement of the largest class of freighted boats, would require capacious reservoirs, and an outlay of some six or, possibly, seven hundred thousand dollars. But merely *to regulate the actual summer discharge*, so as to make it uniform, and supply the additional quantity which would be needed to keep a depth of only four feet on the bar at Wheeling throughout the year, would involve an outlay little, if any, greater than the cost of two of the locks and dams in actual use on the Monongahela navigation.

TABLE VII.

RECORD OF THE DAILY HEIGHT ON THE WHEELING BAR FOR THE YEAR 1846.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	$3\frac{1}{2}$*	17	4	$10\frac{1}{3}$	$8\frac{5}{6}$	9	7	$4\frac{3}{4}$	$4\frac{1}{2}$	$2\frac{1}{4}$	$5\frac{3}{4}$	14
2	$3\frac{1}{2}$*	23	$3\frac{1}{3}$	11	$8\frac{1}{3}$	10	$8\frac{1}{12}$	$4\frac{1}{2}$	$4\frac{1}{3}$	$2\frac{1}{3}$	$5\frac{3}{4}$	16
3	$3\frac{1}{2}$*	$22\frac{1}{2}$	$3\frac{1}{6}$	$10\frac{1}{2}$	13	9	11	4	4	$2\frac{2}{3}$	$6\frac{2}{3}$	$16\frac{1}{2}$
4	$3\frac{1}{2}$*	19	$3\frac{1}{6}$	9	14	9	14	$3\frac{3}{4}$	$4\frac{1}{2}$	$7\frac{7}{12}$	$9\frac{1}{2}$	20
5	$7\frac{1}{2}$	17	$3\frac{1}{2}$	$7\frac{1}{2}$	13	9	9	$3\frac{1}{2}$	4	$2\frac{7}{12}$	$16\frac{1}{2}$	23
6	$7\frac{3}{4}$	14	4	7	11	$8\frac{1}{4}$	$10\frac{1}{2}$	3	$3\frac{2}{3}$	$2\frac{5}{12}$	$13\frac{1}{2}$	20
7	$7\frac{1}{12}$	$12\frac{1}{2}$	$8\frac{1}{2}$	$6\frac{2}{7}$	$10\frac{3}{4}$	$7\frac{2}{3}$	10	$2\frac{1}{12}$	$3\frac{1}{3}$	$2\frac{1}{4}$	10	20
8	$8\frac{1}{4}$	10	18	$6\frac{7}{12}$	$10\frac{1}{2}$	$8\frac{1}{6}$	$10\frac{1}{4}$	$2\frac{2}{3}$	5	$2\frac{1}{6}$	8	18
9	$9\frac{3}{4}$	9	20	$6\frac{1}{6}$	$10\frac{3}{4}$	$7\frac{2}{3}$	$7\frac{1}{4}$	$2\frac{5}{12}$	$4\frac{2}{3}$	$2\frac{1}{12}$	8	19
10	$11\frac{1}{2}$	$8\frac{1}{12}$	18	6	16	$6\frac{1}{3}$	6	$2\frac{2}{3}$	4	2	$7\frac{1}{2}$	28
11	$11\frac{1}{2}$	8	18	$6\frac{5}{6}$	14	$6\frac{1}{4}$	$5\frac{1}{2}$	$2\frac{1}{2}$	$3\frac{5}{6}$	$1\frac{10}{12}$	$7\frac{1}{4}$	22
12	$9\frac{1}{4}$	$7\frac{1}{3}$	$16\frac{1}{2}$	$6\frac{1}{3}$	14	$5\frac{3}{4}$	$4\frac{7}{12}$	$2\frac{2}{3}$	$3\frac{1}{2}$	$1\frac{10}{12}$	$7\frac{1}{3}$	18
13	$9\frac{1}{4}$	$6\frac{1}{12}$	$15\frac{1}{2}$	$5\frac{2}{3}$	14	$5\frac{1}{2}$	$4\frac{1}{4}$	$2\frac{2}{3}$	$3\frac{1}{4}$	$1\frac{3}{4}$	$7\frac{1}{6}$	15
14	8	$6\frac{1}{12}$	19	$5\frac{5}{6}$	$13\frac{1}{2}$	$4\frac{5}{6}$	4	$2\frac{1}{2}$	$3\frac{1}{6}$	$2\frac{1}{2}$	$7\frac{1}{12}$	12
15	$7\frac{5}{12}$	6	35	$5\frac{1}{2}$	$10\frac{1}{2}$	$4\frac{1}{2}$	$3\frac{7}{12}$	3	3	$3\frac{7}{12}$	$7\frac{3}{4}$	14
16	$6\frac{1}{2}$	6	34	$5\frac{3}{4}$	9	$4\frac{1}{3}$	$3\frac{2}{3}$	$3\frac{1}{2}$	$2\frac{1}{12}$	18	$7\frac{2}{3}$	11
17	$8\frac{1}{2}$	$6\frac{1}{6}$	32	$5\frac{1}{2}$	9	$4\frac{3}{4}$	$3\frac{7}{12}$	3	$2\frac{3}{4}$	$11\frac{1}{2}$	$7\frac{2}{3}$	9
18	7	5	26	$5\frac{1}{2}$	16	$4\frac{1}{4}$	$3\frac{1}{3}$	$3\frac{1}{4}$	3	10	$6\frac{1}{2}$	8
19	$6\frac{1}{2}$	$4\frac{5}{6}$	22	$5\frac{1}{3}$	16	5	$3\frac{1}{2}$	$2\frac{7}{12}$	$3\frac{1}{12}$	10	$6\frac{1}{4}$	$7\frac{5}{6}$
20	$7\frac{2}{3}$	$5\frac{1}{6}$	16	5	14	$4\frac{2}{3}$	3	$3\frac{1}{2}$	$3\frac{1}{6}$	$8\frac{1}{4}$	$6\frac{1}{6}$	$6\frac{3}{4}$
21	$7\frac{2}{3}$	$5\frac{1}{6}$	$13\frac{1}{2}$	$4\frac{3}{4}$	11	$5\frac{1}{6}$	$2\frac{1}{12}$	$6\frac{1}{2}$	$3\frac{1}{12}$	$8\frac{1}{4}$	$6\frac{3}{4}$	$6\frac{5}{6}$
22	$6\frac{1}{12}$	$4\frac{7}{12}$	13	$4\frac{7}{12}$	8	$4\frac{2}{3}$	$2\frac{5}{6}$	6	$3\frac{1}{6}$	$7\frac{5}{6}$	12	$6\frac{1}{2}$
23	$5\frac{2}{3}$	$4\frac{1}{6}$	$11\frac{1}{2}$	$4\frac{5}{6}$	8	$4\frac{7}{12}$	$7\frac{7}{12}$	7	$3\frac{1}{3}$	$7\frac{5}{12}$	13	$6\frac{1}{12}$
24	$5\frac{3}{8}$	4	$13\frac{1}{2}$	$4\frac{5}{6}$	$6\frac{1}{2}$	$4\frac{1}{3}$	$7\frac{1}{3}$	10	3	$6\frac{7}{12}$	13	$5\frac{5}{6}$
25	8	$4\frac{5}{6}$	$12\frac{1}{2}$	$4\frac{2}{3}$	$6\frac{1}{2}$	4	7	10	$2\frac{5}{6}$	$5\frac{2}{3}$	13	$5\frac{5}{6}$
26	8	4	$13\frac{1}{2}$	5	$5\frac{1}{2}$	$3\frac{1}{12}$	17	11	$2\frac{2}{3}$	$5\frac{3}{4}$	12	$5\frac{3}{4}$
27	$6\frac{2}{3}$	$4\frac{1}{3}$	13	$6\frac{1}{2}$	$5\frac{1}{4}$	$3\frac{7}{12}$	16	9	$2\frac{7}{12}$	$5\frac{1}{2}$	11	$7\frac{1}{2}$
28	$7\frac{1}{4}$	4	16	8	$7\frac{1}{2}$	$3\frac{3}{4}$	$7\frac{3}{4}$	6	$2\frac{1}{2}$	5	$10\frac{1}{2}$	10
29	$7\frac{1}{4}$	–	15	$7\frac{1}{2}$	$11\frac{1}{2}$	$3\frac{1}{3}$	$7\frac{1}{3}$	5	$2\frac{3}{4}$	$4\frac{2}{3}$	10	$11\frac{1}{2}$
30	$9\frac{1}{6}$	–	$14\frac{1}{2}$	$7\frac{1}{12}$	12	$3\frac{1}{3}$	$6\frac{2}{3}$	$5\frac{1}{4}$	$2\frac{7}{12}$	$4\frac{1}{2}$	11	20
31	$10\frac{1}{4}$	–	11	–	$8\frac{1}{2}$	–	5	$5\frac{1}{2}$	–	$4\frac{1}{3}$	–	18
Discharge in each month in cubic feet.	53,523,000,000	77,954,000,000	197,286,000,000	42,232,000,000	102,801,000,000	35,929,000,000	56,223,000,000	27,789,000,000	14,683,000,000	35,951,000,000	75,022,000,000	159,726,000,000
Eq. mo. heights.	$7\frac{60}{100}$	$10\frac{6}{100}$	$16\frac{40}{100}$	$6\frac{72}{100}$	$11\frac{19}{100}$	$6\frac{10}{100}$	$7\frac{80}{100}$	$5\frac{12}{100}$	$3\frac{42}{100}$	6	$9\frac{35}{100}$	$14\frac{50}{100}$

Annual discharge, 879,119,000,000 cubic feet; equiv. uniform depth, $9\frac{22}{100}$.

* Closed by ice.

The analysis of the tabulated results for 1846, shows that the total drainage of the Ohio river for that year was—

879,119,000,000 cubic feet;

and the average daily discharge—

2,409,000,000 cubic feet.

If the discharge had been uniform throughout the year, the depth of the water on the bar at Wheeling would have been constantly $9\frac{22}{100}$ feet.

The drainage from the whole surface of the country was, for the year, $1\frac{297}{1000}$ feet; or,

$15\frac{56}{100}$ inches.

The greatest monthly drainage was in March, and amounted to—

$3\frac{1}{2}$ inches;

and the least monthly drainage again in September, when it amounted to—

$\frac{26}{100}$ of an inch.

The practical results of the inquiry for this year, also, are exceedingly interesting. We find, by reference to the table of heights on the bar, that in the beginning of the month of January, as at the close of the previous December, the water fell to $3\frac{1}{2}$ feet in the channel, and the river was then closed by ice. But experience has shown that this river never freezes at Wheeling, excepting when the water falls so low that the ice grounds on the bars and chokes the channel. Consequently, if the proper depth of water were maintained in the river, so that the ice, instead of lodging, would be carried by a brisk current over the bars, it could not jam and form dams, behind which the still water could freeze and the floating particles collect.

The whole period of low water, and consequent stoppage of the navigation in December, 1845, and January, 1846, was but 14 days; and the whole quantity of water which would have been required, over and above the actual flow, was but 660,000,000 cubic feet per diem, or 9,240,000,000 altogether, for the 14 days, to have maintained a depth of *six feet* constantly in the channel.

Now, there are many places upon the upper tributaries of the Ohio, where a dam 45 feet high would form a sufficient reservoir to furnish this quantity; and an inspection of the records in this paper will show that such a reservoir may be emptied many times during every winter, with full confidence that it will be promptly replenished by the rains and melted snows.

But we observe by the table of heights for 1846, that the river was not only low at the end of December and the beginning of January, when a discharge of water was needed to carry off the ice and restore the navigation; but that it rose and fell also in February, so as again to require aid from the artificial store: that it was down also in March as low as $3\frac{1}{6}$ feet—a depth too little for the first

class of boats to run, even if empty, in safety—although the total discharge of the river during that very month was sufficient to have maintained an uniform draught of $16\frac{4}{10}$ feet. In fact, there was but one month in the whole year in which the discharge for the month, if properly regulated, would not have preserved the depth on the Wheeling bar at more than 5 feet; yet, there were periods in eight months of that year when boats drawing over four feet could not have run, and other periods, in the summer season, when boats drawing over $2\frac{1}{2}$ feet could not pass the bar. Still, three dams of very moderate height, not exceeding 40 feet each, and which need not be made to cost more than about $300,000, would so have regulated the discharge that the depth could never have fallen, during any part of the year, below 5 feet.

In the month of October the depth was less than 2 feet, and for about half the month it was less than three feet. Yet, the volume of water which passed by Wheeling even in October, would have maintained an uniform depth of 6 feet throughout that month.

By means of only three dams, from 40 to 50 feet high, or a greater number of smaller dimensions, a fresh supply of water could have been let into the stream in January, when the river was frozen over, which would have raised the surface, increased the velocity, and swept away the ice, and have thus restored the winter navigation. The reservoirs, it will be seen by reference to the table, would have been filled again immediately, and would have been ready, in February, to bring the water up from 4 feet to 6 feet, and again, in March, from 3 feet 2 inches to 6 feet.

At the close of March, and early in April, they would have been replenished by the melted snows, and in the course of April would have been once more needed to raise the water from $4\frac{1}{2}$ feet to 6 feet—two dams of 50 feet being quite sufficient to maintain this depth. In May and June the reservoirs would have been again filled; but about the middle of June their contents would have been required to increase the depth, then down nearly to 3 feet, and bring it up to 5 or, if desirable, to 6 feet.

In the beginning of July the reservoirs would have been again filled by the rains, and in the middle of the same month again drawn upon to raise the water from 2 feet 10 inches—a depth entirely prohibitory of navigation for boats of the best class—and bring it up to 6 feet.

On the 23d of July the natural flow from the mountains increased, the water rose to 17 feet, and the reservoir would, of course, have been filled again. But early in August, the failing supply would have called for further aid from the artificial store: the waters might have been again raised to 6 feet; and by the 21st, the reservoirs would have ceased their discharge, and have been filled again by the swollen mountain sources.

In September the water is always low. But the same two regulating reservoirs would, nevertheless, have kept up the depth to 5 feet until the middle of October, when a rise of 18 feet would have filled them once more. But near the end of October the supply again failed, and the depth fell to $4\frac{1}{3}$ feet. The

same reservoirs, having been replenished by the preceding flood, would, however, have brought it up again to 6 feet or more. In November and December the natural flow of the river required no aid.

No less than ten times in the course of the year 1846 the navigation could have been maintained at a height, generally of 6, and never less than 5 feet, by means of three reservoirs of moderate size, of which the total cost could not exceed that of twelve or fifteen miles of ordinary railroad.

The same object may be accomplished with equal certainty, and probably for an outlay not materially greater, without the necessity of placing any dams across the principal tributaries of the Ohio. The smaller branches, nearer to the mountains, abound in eligible sites for reservoirs, where an ample store of water may be accumulated in numerous lakes of inconsiderable dimensions, and where no land need be submerged, nor other valuable property damaged by the works. There are some important advantages to be gained by selecting these remote sites for retaining at least a part of the store. The smaller streams not being navigable, no costly locks will be required to accommodate the trade; while the construction of the dams will be rendered exceedingly cheap by the abundance of excellent materials, and the firm foundations which the rocky valleys afford. The reservoirs that will there be formed will be surrounded by precipitous cliffs, and quite secluded from all public and private interests. In such positions the mass of water may be retained, while the great streams need not be resorted to at all; or if used, used only as the sites of capacious *regulating reservoirs*, corresponding in their functions with the distributing basins of common water-works.

TABLE VIII.

RECORD OF THE DAILY HEIGHT ON THE WHEELING BAR FOR THE YEAR 1845.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	9	9	12	$8\frac{1}{2}$	7	$2\frac{5}{6}$	$6\frac{1}{2}$	$2\frac{11}{12}$	$2\frac{1}{2}$	5	$3\frac{1}{4}$	4
2	8	8	11	9	8	$2\frac{1}{3}$	$5\frac{1}{2}$	$2\frac{5}{6}$	$2\frac{5}{6}$	$4\frac{3}{4}$	$3\frac{1}{4}$	$4\frac{3}{4}$
3	7	7	$9\frac{1}{2}$	8	$7\frac{1}{4}$	$2\frac{1}{4}$	$5\frac{1}{2}$	$2\frac{3}{4}$	$2\frac{1}{3}$	$4\frac{3}{4}$	$3\frac{1}{2}$	$3\frac{7}{12}$*
4	$6\frac{1}{2}$	$6\frac{1}{2}$	8	$7\frac{3}{4}$	8	$2\frac{1}{2}$	$6\frac{1}{2}$	$2\frac{5}{6}$	$3\frac{1}{6}$	$4\frac{3}{4}$	$4\frac{1}{4}$	$3\frac{1}{2}$*
5	$6\frac{1}{2}$	6	$7\frac{3}{4}$	$7\frac{1}{4}$	$8\frac{1}{4}$	$2\frac{7}{12}$	$8\frac{1}{6}$	$2\frac{11}{12}$	$3\frac{1}{3}$	5	$4\frac{2}{3}$	$3\frac{1}{2}$*
6	6	$5\frac{3}{4}$	13	7	$7\frac{1}{2}$	$2\frac{5}{12}$	9	3	$2\frac{11}{12}$	6	7	$3\frac{1}{2}$*
7	7	$5\frac{1}{2}$	18	$6\frac{1}{2}$	7	$2\frac{1}{4}$	8	$2\frac{5}{6}$	4	$6\frac{1}{2}$	$7\frac{1}{2}$	$3\frac{1}{2}$*
8	7	$5\frac{1}{2}$	20	6	7	$2\frac{7}{12}$	8	$2\frac{2}{3}$	$4\frac{1}{2}$	$5\frac{3}{4}$	$6\frac{2}{3}$	$7\frac{1}{2}$*
9	$7\frac{1}{2}$	5	20	6	7	$2\frac{1}{6}$	$5\frac{5}{6}$	$2\frac{7}{12}$	$3\frac{5}{6}$	6	$6\frac{7}{12}$	5*
10	8	5	19	5	$6\frac{1}{2}$	$2\frac{7}{12}$	$6\frac{1}{4}$	$2\frac{5}{6}$	$3\frac{1}{4}$	$6\frac{5}{6}$	$6\frac{1}{2}$	5*
11	7	5	22	5	6	$2\frac{5}{12}$	$5\frac{1}{4}$	$2\frac{7}{12}$	$3\frac{1}{6}$	$6\frac{5}{6}$	7	5*
12	6	5	24	5	$5\frac{1}{2}$	$2\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{11}{12}$	10	$7\frac{1}{2}$	8
13	6	$5\frac{1}{2}$	22	$4\frac{1}{2}$	$5\frac{1}{3}$	$2\frac{1}{2}$	4	$2\frac{7}{12}$	$2\frac{3}{4}$	10	$8\frac{1}{4}$	$7\frac{5}{12}$
14	6	8	20	$4\frac{2}{3}$	5	$2\frac{5}{6}$	$3\frac{3}{4}$	$2\frac{2}{3}$	$2\frac{1}{3}$	$11\frac{1}{2}$	$7\frac{7}{12}$	6
15	6	$10\frac{1}{2}$	17	$4\frac{1}{4}$	$4\frac{5}{6}$	$3\frac{1}{4}$	$3\frac{5}{12}$	$2\frac{2}{3}$	$2\frac{5}{12}$	15	$7\frac{1}{3}$	$5\frac{5}{12}$
16	5	13	15	$4\frac{1}{6}$	$4\frac{2}{3}$	$3\frac{1}{4}$	$3\frac{1}{4}$	$2\frac{5}{6}$	$2\frac{1}{4}$	$13\frac{1}{2}$	7	$5\frac{1}{6}$
17	$5\frac{1}{2}$	14	13	4	$4\frac{1}{2}$	$3\frac{1}{2}$	3	$2\frac{1}{2}$	$2\frac{5}{12}$	12	$6\frac{5}{6}$	$4\frac{11}{12}$
18	9	13	11	$3\frac{5}{6}$	$4\frac{1}{12}$	4	$2\frac{11}{12}$	$2\frac{3}{4}$	$2\frac{1}{4}$	10	$6\frac{1}{3}$	$5\frac{1}{4}$
19	19	13	11	$3\frac{2}{3}$	$3\frac{1}{2}$	4	$2\frac{5}{6}$	$3\frac{1}{4}$	$2\frac{1}{6}$	$7\frac{1}{2}$	$5\frac{7}{12}$	$6\frac{3}{4}$
20	21	11	$9\frac{1}{2}$	$4\frac{2}{3}$	$3\frac{5}{6}$	4	$3\frac{1}{12}$	$3\frac{1}{4}$	$2\frac{5}{12}$	$7\frac{1}{2}$	$5\frac{1}{3}$	$6\frac{1}{2}$
21	17	10	9	$3\frac{7}{12}$	$3\frac{2}{3}$	$3\frac{3}{4}$	$2\frac{2}{3}$	3	$2\frac{5}{6}$	$6\frac{1}{2}$	$5\frac{1}{3}$	5*
22	15	9	8	$3\frac{1}{2}$	$3\frac{1}{6}$	4	$2\frac{1}{2}$	$2\frac{5}{6}$	3	6	$5\frac{1}{6}$	$5\frac{1}{2}$*
23	14	11	8	$3\frac{2}{3}$	3	$5\frac{1}{6}$	$2\frac{5}{12}$	$2\frac{3}{4}$	3	$5\frac{1}{4}$	$5\frac{7}{12}$	5*
24	11	14	$7\frac{1}{2}$	4	3	$4\frac{3}{4}$	$2\frac{5}{12}$	$3\frac{1}{12}$	$3\frac{1}{2}$	$4\frac{3}{4}$	5	$4\frac{1}{2}$*
25	15	16	8	$4\frac{1}{2}$	$3\frac{1}{3}$	12	$2\frac{3}{4}$	$3\frac{1}{6}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$5\frac{5}{6}$	4*
26	16	16	$7\frac{1}{2}$	$4\frac{1}{4}$	$2\frac{11}{12}$	14	4	$3\frac{1}{6}$	$4\frac{3}{4}$	4	$4\frac{2}{3}$	4*
27	16	$15\frac{1}{2}$	$7\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{5}{6}$	11	$3\frac{3}{4}$	3	$4\frac{1}{2}$	4	$3\frac{11}{12}$	$3\frac{5}{12}$*
28	13	14	$6\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{5}{6}$	$8\frac{1}{2}$	$3\frac{3}{4}$	$2\frac{3}{4}$	$4\frac{5}{6}$	$3\frac{5}{6}$	$3\frac{3}{4}$	3*
29	11	–	$6\frac{1}{2}$	4	$2\frac{3}{4}$	$5\frac{5}{6}$	$3\frac{1}{2}$	$2\frac{3}{4}$	$5\frac{1}{2}$	$3\frac{3}{4}$	$4\frac{1}{3}$	3*
30	10	–	8	$5\frac{1}{2}$	$2\frac{2}{3}$	7	3	$2\frac{3}{4}$	$5\frac{1}{2}$	$3\frac{2}{3}$	$4\frac{1}{12}$	3*
31	$9\frac{1}{2}$	–	$7\frac{1}{2}$	–	$2\frac{2}{3}$	–	$2\frac{11}{12}$	$2\frac{5}{12}$	–	$3\frac{1}{3}$	–	3*
Discharge in each month in cubic feet.	93,843,000,000	77,542,000,000	136,774,000,000	29,672,000,000	29,082,000,000	26,774,000,000	25,075,000,000	11,340,000,000	14,532,000,000	50,557,000,000	33,601,000,000	26,690,000,000
Eq. mo. heights.	$10\frac{59}{100}$	$9\frac{95}{100}$	$13\frac{24}{100}$	$5\frac{45}{100}$	$5\frac{26}{100}$	$5\frac{10}{100}$	$4\frac{87}{100}$	$2\frac{82}{100}$	$3\frac{40}{100}$	$7\frac{34}{100}$	$5\frac{86}{100}$	5
Annual discharge, 555,482,000,000 cubic feet ; equiv. uniform depth, 7.03 feet.												

* Closed by ice.

The total drainage of the Ohio, above Wheeling, for the year 1845, was but—

555,482,000,000 cubic feet;

and the average daily discharge—

1,522,000,000 cubic feet

Comparing these with the corresponding results for 1847, we observe the curious fact, that rather more than twice as much water was shed from the country drained by the tributaries of the Ohio, in the year 1847, as in 1845.

It is possible that an inspection of the observations on the fall of rain for those two years, in the same region, may show that the actual fall was greater in 1847 than in 1845—a fact which would alone explain this result. But it is by no means certain that the year in which there is the greatest number of inches of rain and snow indicated by the gauge, is also that which will exhibit the greatest discharge by the rivers of the country. The volume discharged depends more on the season when the rain falls, and the quantities falling in a given period, than upon the actual annual supply. Much of the winter's rain lies congealed upon the mountains, and at the northern sources of the stream, and suffers but little loss from evaporation, until the first general thaw dissolves the snows, and the whole quantity collected is poured off in a flood; while that which falls in summer showers is evaporated at once, or absorbed by the dry earth, to be slowly evaporated before it can affect the springs.

A slight change of circumstances affects the annual discharge. The early winter may be too mild to produce heavy snows, and the rain may pass off in floods in December; or it may be so severe as to freeze all the moisture that reaches the earth, so that it will be retained in the hills until the approach of the next spring. If the water which falls, runs off in December, it will affect the discharge for the year which closes with December. But if retained in the form of snow, it will be held over, and serve to swell the discharge of the succeeding spring.

These irregularities may be accounted for, to a great extent, without assuming corresponding irregularities in the fall of rain. Yet, the difference between the quantities which passed from the upper Ohio to the Ocean, in 1845 and 1847 respectively, may really be due, in part, to a difference in the amounts of rain which actually fell in the respective years. The writer has neither library nor meteorological record at his command, and cannot now properly investigate this branch of his subject.

The quantity of water which flowed down the Ohio in 1845, was sufficient to have maintained an uniform depth on the bar at Wheeling, throughout the year, of $7\frac{3}{100}$ feet.

The drainage of the whole country, for this year, was equal to $\frac{819}{1000}$ of a foot; or,

$9\frac{83}{100}$ inches.

The greatest monthly drainage was in March, when it amounted to—

$2\frac{4}{10}$ inches:

and the least monthly drainage in August, when it was but—

$\frac{204}{1000}$ of an inch.

In every month of the year 1845, from April to December, including both, one or two periods of low water occurred, requiring the aid of the artificial supply. Indeed, throughout the whole space of eleven years, which the authentic records cover, there is found no year in which the navigation of the Ohio was more precarious than in the year 1845, when it was subject to frequent and total interruptions, both from ice and low water.

To have maintained a depth of 5 feet in the channel throughout that year, the reservoirs would have been drawn upon *twelve times*, and would have been filled again eleven of those times by the surplus which was wasted during the same month. Even in this year, small as was the quantity which the tributaries furnished, and frequent as were the periods of deficiency, the greatest volume needed to be accumulated in the reservoirs at any time, was but 28,744,000,000 cubic feet. In the months of July, August, and September, there was a period of 79 consecutive days, when the depth on the Wheeling bar was less than 5 feet; yet the deficiency for all that period was less than 29,000,000,000 cubic feet—a volume no larger than can be collected in three or four reservoirs, which, on almost any part of the Monongahela or Alleghany, could be formed by dams from 35 to 40 feet high.

Yet, as all the objections that can possibly be urged against the construction of high dams on these great rivers may be obviated, as already stated, by resorting to the smaller affluents, it will be the aim of the writer to make a first demonstration of his plan in localities remote from the leading channels of trade, and where there are no important private interests to be consulted.

The only natural lake that would be at all available for this object is the Chatauque, of which the waters flow into the Alleghany, above Warren. But this beautiful basin is itself filled from an area of country too small to contribute any material supply for the purposes here contemplated, and cannot, therefore, be resorted to with profit.

TABLE IX.

RECORD OF THE DAILY HEIGHT ON THE WHEELING BAR FOR THE YEAR 1844.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	11	5	7	13	7	7	8	6	5	$2\frac{7}{8}$	14	9
2	10	5	8	12	7	9	7	7	5	$2\frac{7}{8}$	11	8
3	9	$4\frac{1}{2}$	8	11	6	10	6	8	5	4	10	8
4	9	$4\frac{1}{2}$	10	10	7	9	6	7	$5\frac{2}{3}$	4	10	9
5	8	5	14	10	9	8	8	6	7	$3\frac{2}{3}$	12	9
6	8	6	13	9	11	7	9	$5\frac{2}{3}$	6	$3\frac{2}{3}$	16	9
7	8	7	11	9	9	$6\frac{1}{3}$	8	5	$5\frac{2}{3}$	$3\frac{2}{3}$	15	9
8	7	$6\frac{2}{3}$	9	11	8	6	7	$4\frac{2}{3}$	$4\frac{2}{3}$	$3\frac{1}{4}$	13	9
9	7	6	9	12	$7\frac{2}{3}$	$5\frac{2}{3}$	13	4	4	$3\frac{1}{4}$	11	10
10	7	$5\frac{2}{3}$	12	12	8	5	10	4	4	$3\frac{1}{8}$	10	14
11	$6\frac{1}{3}$	5	13	12	$7\frac{1}{3}$	$4\frac{2}{3}$	7	4	$3\frac{2}{3}$	3	8	12
12	5	$4\frac{1}{3}$	14	11	$7\frac{1}{3}$	$4\frac{1}{3}$	6	4	$3\frac{1}{4}$	3	7	10
13	6	$4\frac{1}{3}$	15	11	7	$4\frac{1}{3}$	5	$3\frac{2}{3}$	$3\frac{1}{8}$	$2\frac{2}{3}$	8	9
14	7	$4\frac{1}{3}$	16	10	8	$4\frac{1}{3}$	$5\frac{1}{3}$	$4\frac{1}{3}$	3	$2\frac{2}{3}$	11	8
15	11	5	17	9	8	5	5	4	$2\frac{5}{8}$	$2\frac{5}{8}$	14	7
16	10	5	16	8	8	10	$4\frac{1}{3}$	$3\frac{1}{3}$	$2\frac{2}{3}$	$2\frac{1}{3}$	12	6
17	9	5	17	7	8	9	$4\frac{1}{3}$	$3\frac{1}{4}$	$2\frac{1}{3}$	$2\frac{2}{3}$	10	6
18	9	$4\frac{1}{3}$	18	$6\frac{1}{3}$	9	7	4	$3\frac{1}{3}$	$2\frac{1}{3}$	3	9	$5\frac{2}{3}$
19	9	$4\frac{2}{3}$	19	6	12	6	$4\frac{2}{3}$	3	$2\frac{1}{3}$	5	9	$5\frac{1}{4}$
20	8	$4\frac{2}{3}$	17	6	12	$5\frac{1}{4}$	5	3	$2\frac{1}{4}$	8	8	5
21	8	$4\frac{1}{4}$	15	$5\frac{1}{4}$	11	$6\frac{1}{4}$	$5\frac{1}{4}$	$3\frac{1}{4}$	$2\frac{1}{8}$	10	7	$4\frac{1}{4}$
22	7	5	13	$5\frac{1}{4}$	11	6	5	$3\frac{1}{4}$	2	8	7	$4\frac{1}{4}$
23	7	$5\frac{1}{4}$	12	5	14	$5\frac{1}{4}$	$5\frac{1}{4}$	4	$1\frac{1}{8}$	7	7	$4\frac{1}{4}$
24	8	6	11	$4\frac{1}{4}$	13	9	5	$4\frac{1}{4}$	$1\frac{1}{8}$	6	8	$4\frac{1}{4}$
25	14	7	10	$4\frac{1}{4}$	11	9	$4\frac{1}{4}$	$5\frac{1}{4}$	$1\frac{1}{8}$	$5\frac{1}{4}$	7	5
26	11	$6\frac{1}{4}$	9	4	9	8	4	6	$1\frac{2}{3}$	5	7	5
27	10	$6\frac{1}{4}$	8	4	8	7	$4\frac{1}{2}$	$5\frac{1}{4}$	$1\frac{1}{4}$	5	6	5
28	9	6	8	5	7	8	$5\frac{1}{2}$	5	$1\frac{1}{8}$	$4\frac{1}{8}$	6	7
29	7	$6\frac{5}{8}$	8	$5\frac{5}{8}$	$6\frac{5}{8}$	$7\frac{5}{8}$	10	$5\frac{7}{8}$	$1\frac{1}{8}$	6	6	11
30	7	–	9	7	8	8	9	5	$1\frac{1}{8}$	14	6	11
31	$6\frac{5}{8}$	–	10	–	7	–	7	5	–	16	–	10
Discharge in each month in cubic feet.	64,936,000,000	28,523,000,000	123,840,000,000	62,753,000,000	70,656,000,000	45,954,000,000	42,628,000,000	25,446,000,000	14,577,000,000	33,361,000,000	79,624,000,000	58,684,000,000
Eq. mo. heights.	$8\frac{50}{100}$	$5\frac{43}{100}$	$12\frac{50}{100}$	$8\frac{32}{100}$	$8\frac{92}{100}$	$7\frac{6}{100}$	$6\frac{62}{100}$	$4\frac{82}{100}$	$3\frac{41}{100}$	$5\frac{68}{100}$	$9\frac{78}{100}$	8

Annual discharge, 650,982,000,000 cubic feet; equiv. uniform depth, 7.725 feet.

The discharge of the Ohio, calculated from the data offered in the foregoing record, exhibits for the volume of water which flowed past Wheeling in 1844, a season of more than ordinary dryness,

650,982,000,000 cubic feet;

and for the average daily discharge,

1,779,000,000 cubic feet;

and for the uniform height which this quantity would have maintained upon the bar at Wheeling,

$7\frac{726}{1000}$ feet.

The drainage of the country for that year was $\frac{96}{100}$ of a foot; or,

$11\frac{52}{100}$ inches;

which is almost precisely the amount ordinarily assumed by engineers as the supply that may be relied on for canal feeders, but by no means that which ought to be uniformly anticipated. There is, in fact, scarcely an approach to uniformity in the annual discharge of streams in this climate.

The practical conclusions drawn from the analysis of the record for the year 1844 are also important. During a portion of September the water fell below 14 inches on Wheeling bar; and both in August and October it was down as low as 3 feet, or less. Yet, the irregular discharge for the month of August was sufficient to have maintained an uniform depth, throughout that month, of $4\frac{83}{100}$ feet; and it would have required no greater accession to the natural supply of the stream, if this supply had been properly regulated by art, to maintain an uniform depth of 5 feet, than would be afforded by many of the dams actually erected and in use on the navigable rivers of this country.

In the month of September the water was down as low as $1\frac{1}{8}$ foot; yet a single dam on the Alleghany, and one other on the Monongahela—neither being larger than those already built by the Monongahela Navigation company—properly constructed, and supplied with appropriate gates, would have been all-sufficient to have regulated the actual discharge, and maintained an uniform depth of 4 feet throughout that month.

It may be stated as a general fact, which can be fully demonstrated by these measurements, that two dams, no higher than the Blue Mountain dam on the Schuylkill navigation—one of which should arrest the waters of the Alleghany, and the other those of the Monongahela—could be safely relied on for permanently maintaining a depth of 4 feet, and clearing the river effectually of obstruction from ice, so that the navigation for boats of that draught need be subject to no future interruptions. A depth of 4 feet will permit the best class of Pittsburg and Cincinnati packets to run all the year; and this result could have been easily obtained in 1844 for a sum not exceeding $300,000.

TABLE X.

RECORD OF THE DAILY HEIGHT ON THE WHEELING BAR FOR THE YEAR 1843.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	5	13	7	17	18	10	4	$2\frac{1}{4}$	$1\frac{7}{8}$	7	$7\frac{5}{8}$	7
2	6	14	7	20	17	9	4	$2\frac{1}{4}$	$1\frac{7}{8}$	$5\frac{5}{8}$	7	7
3	6	13	6	18	17	8	$3\frac{7}{8}$	$2\frac{1}{4}$	$1\frac{7}{8}$	5	$6\frac{3}{8}$	$6\frac{3}{8}$
4	$6\frac{3}{8}$	11	6	17	16	8	$3\frac{1}{3}$	2	$1\frac{7}{8}$	$4\frac{3}{8}$	6	$6\frac{3}{8}$
5	$6\frac{3}{8}$	10	5	16	14	12	$3\frac{3}{8}$	2	$1\frac{7}{8}$	4	6	6
6	7	9	5	15	12	17	$3\frac{1}{3}$	2	2	4	$5\frac{3}{8}$	$5\frac{5}{8}$
7	7	8	$4\frac{5}{8}$	17	10	19	$3\frac{1}{3}$	2	2	4	$5\frac{3}{8}$	$5\frac{3}{8}$
8	8	7	$4\frac{5}{8}$	17	8	16	$3\frac{1}{4}$	2	$2\frac{1}{3}$	4	5	$5\frac{3}{8}$
9	9	7	$4\frac{3}{8}$	18	8	13	3	2	3	4	5	5
10	10	6	8	20	8	11	$2\frac{7}{8}$	2	5	7	5	5
11	12	6	10	20	8	12	$2\frac{3}{4}$	2	7	10	6	5
12	20	6	13	17	9	16	$2\frac{3}{4}$	$1\frac{7}{8}$	6	9	9	$4\frac{2}{3}$
13	25	$6\frac{1}{2}$	13	15	10	16	$2\frac{5}{8}$	$1\frac{7}{8}$	7	8	12	5
14	26	7	13	15	10	14	$2\frac{5}{8}$	$1\frac{7}{8}$	9	8	18	8
15	20	7	12	18	9	12	9	$1\frac{7}{8}$	9	7	15	7
16	17	7	10	18	10	12	7	$1\frac{7}{8}$	9	$6\frac{1}{2}$	12	8
17	12	7	9	22	8	10	$5\frac{1}{2}$	$1\frac{2}{3}$	20	$6\frac{5}{8}$	10	10
18	11	7	$7\frac{1}{2}$	25	7	12	$4\frac{1}{2}$	$1\frac{2}{3}$	15	$6\frac{3}{8}$	9	16
19	10	7	7	27	6	13	$4\frac{5}{8}$	$1\frac{2}{3}$	10	$6\frac{3}{8}$	10	20
20	9	8	$6\frac{3}{8}$	26	$5\frac{3}{8}$	11	4	$1\frac{2}{3}$	9	7	12	18
21	8	8	6	24	$5\frac{5}{8}$	9	$3\frac{7}{8}$	$1\frac{2}{3}$	8	8	14	16
22	8	11	$5\frac{5}{8}$	22	5	8	$3\frac{3}{8}$	$1\frac{7}{8}$	7	8	15	12
23	8	10	5	18	5	7	3	$1\frac{7}{8}$	6	9	15	12
24	10	9	5	20	$4\frac{2}{3}$	6	3	$1\frac{3}{4}$	5	9	14	16
25	10	9	$4\frac{3}{8}$	21	$4\frac{2}{3}$	$5\frac{3}{8}$	3	$1\frac{3}{4}$	$4\frac{3}{8}$	8	12	18
26	9	8	$4\frac{5}{8}$	20	$4\frac{3}{4}$	5	$2\frac{3}{4}$	$1\frac{3}{4}$	$4\frac{5}{8}$	7	11	17
27	9	8	$4\frac{1}{4}$	19	$4\frac{3}{4}$	5	$2\frac{5}{8}$	$1\frac{3}{4}$	$4\frac{5}{8}$	7	10	15
28	8	8	6	17	$5\frac{5}{8}$	$4\frac{5}{8}$	$2\frac{1}{4}$	$1\frac{7}{8}$	6	7	9	14
29	10	–	12	19	7	4	$2\frac{1}{4}$	$1\frac{7}{8}$	10	$7\frac{5}{8}$	8	13
30	11	–	18	19	9	4	$2\frac{1}{8}$	$1\frac{7}{8}$	9	$7\frac{5}{8}$	7	13
31	11	–	17	–	11	–	$2\frac{1}{8}$	$1\frac{7}{8}$	–	$7\frac{5}{8}$	–	12
Discharge in each month, in cubic feet.	109,193,000,000	60,568,000,000	65,215,000,000	251,449,000,000	78,393,000,000	94,841,000,000	17,815,000,000	6,684,000,000	47,471,000,000	46,063,000,000	82,890,000,000	100,800,000,000
Eq. mo. heights.	$11\frac{60}{100}$	$8\frac{65}{100}$	$8\frac{50}{100}$	$19\frac{40}{100}$	$9\frac{50}{100}$	$10\frac{87}{100}$	$3\frac{80}{100}$	$1\frac{90}{100}$	$7\frac{20}{100}$	$6\frac{93}{100}$	10	$11\frac{5}{100}$

Annual discharge, 961,382,000,000 cubic feet; equiv. uniform depth, 9.73.

It appears from the foregoing record that the volume of water which flowed down the Ohio at Wheeling, in 1843, amounted to—

961,382,000,000 cubic feet;

and that the equivalent average daily supply is—

2,634,000,000 cubic feet.

This quantity is sufficient to maintain an uniform height throughout the year, upon the Wheeling bar, of—

$9\frac{73}{100}$ feet.

The total drainage for that year was $1\frac{417}{1000}$ feet, or—

17 inches.

The greatest monthly drainage was in April, when it amounted to—

$4\frac{44}{100}$ inches;

and the least monthly drainage in August, when it amounted only to—

$\frac{12}{100}$ of an inch.

If we look over the values of the monthly drainage for the six years which have been analyzed, it will be observed that the volume of water which passed down the Ohio in April, 1843, was greater than the amount shed during any other month in all that period; while the amount discharged in August, 1843, was less than the discharge of any other month in the same space of six years.

The results of this year's analysis show, also, that the navigation might have been very easily maintained at a height of more than 5 feet, by two or three reservoirs of very moderate capacity.

It is not necessary to multiply observations bearing on a fact already sufficiently explained. The capability of the upper branches of the Ohio to furnish adequate reservoir sites will be alluded to in the sequel. It is sufficient to say here, that the navigation may be permanently upheld, free from all obstruction from ice or drought, by the construction of a few dams across its tributary streams, and providing those dams with locks for the convenience of the local trade, and appropriate pipes and valves for drawing off the water held in reserve, as it is needed.

The same dams that will serve to supply the channel with water in the summer months, and sweep away the ice which collects during the low water of winter, will enable us also to shut off the water entirely, so as to lay bare the bars when it is desirable to do so, to remove obstructions, and, as we shall presently see, even to hold back the floods, when they threaten to desolate the valley below. In fact, we can exercise as complete control over this great river as we possess over the discharge of a hydrant.

AVERAGES OF THE PRECEDING RESULTS.

In collecting the foregoing results, we obtain the following averages for a period of six years:

The total discharge of the Ohio in—

1843	was	961,382,000,000	cubic feet.
1844	"	650,982,000,000	" "
1845	"	555,482,000,000	" "
1846	"	879,119,000,000	" "
1847	"	1,142,258,000,000	" "
1848	"	822,719,000,000	" "
Total for six years		5,011,942,000,000	" "
Annual average		835,323,000,000	" "
Daily average, for six years		2,287,000,000	" "

By applying the formula, or Table IV, we find that this quantity is just sufficient to have maintained the river at an uniform height of $8\frac{94}{100}$ feet during this entire period of six years.

The annual drainage, as we have seen, in—

1843	was	17	inches.
1844	"	$11\frac{52}{100}$	"
1845	"	$9\frac{83}{100}$	"
1846	"	$15\frac{56}{100}$	"
1847	"	$20\frac{20}{100}$	"
1848	"	$14\frac{57}{100}$	"
Total drainage for six years		$88\frac{67}{100}$	"
Annual average		$14\frac{778}{1000}$	"

The average annual fall of rain at the head of the Ohio is about 36 inches. The discharge is therefore about 40 per cent. of the total fall; showing that 60 per cent. of all the rain and snow that come to the earth in this latitude is carried back to the clouds in vapor, and never reaches the Ocean.

There are, doubtless, meteorological records which would enable us to state the average annual fall of rain in the district of country which is drained by the upper Ohio, more accurately than it is here given, for these six years; but the engagements and present position of the writer have not permitted him to pursue that subject minutely.

The average result here stated, however—40 per cent. for the drainage, and 60 per cent. for the evaporation and vegetable consumption—will be found to be very nearly the proportions in which the total fall of rain, in this climate, is actually divided.

OF THE FLOODS OF THE OHIO.

The records exhibited in the preceding pages, and the volumes of water discharged in periods of twenty-four hours, when the river is at given heights, shown in Table IV, are useful in another application. They teach us the important fact, that the great floods of this river may be so controlled as to be deprived of their destructive power, and forced, by the hand of man, to glide harmlessly to their place in the Ocean.

A flood in a great river, like the Ohio, is but A WAVE, spreading along a limited portion of its course. The banks of the stream are only overflowed by water from the same tributary, for a very short distance at the same time, and the channel of the river is never filled simultaneously from its source to its mouth. When there is a great rise at Pittsburg, there is no perceptible rise, produced by water from the Alleghany and Monongahela, at Louisville; and when the flood originating at Pittsburg has reached Louisville, the water has always subsided again at Pittsburg.

A great flood in the upper Ohio rarely continues at its extreme height more than ten or twelve hours; and but a single instance can be found in the records of the last eleven years, of a rise which continued at a greater height than 25 feet at Wheeling, longer than four days. When the river is at its highest mark at any point, as it usually remains at that level but the fraction of a day, it is rising 100 miles below, and falling 100 miles above; it has quite a moderate rise 200 miles below; and has receded again, within moderate bounds, 200 miles above. From these extremes it rises towards the point which, for the moment, is the top of the swell, forming *a wave*, represented in—

FIG. 3.

This figure is not designed to show the absolute form of the wave, the height of which is due to the difference between the inclination of the surface during the flood, and in the ordinary regimen of the stream; and varies from hour to hour, as the supply becomes greater or less than, or just equal to, the discharge. The slope of the river is not represented in the cut, and the height of the wave is greatly exaggerated. In fact, the surface descends from A to C, although C is, compared with the summer level of the stream, higher than A.

At the point A the river may have fallen to 25 feet, and at the point B it may have risen to 25 feet above low water; while at C, the centre of the swell, it might stand—as during the great flood of 1832, at Wheeling—44½ feet above

low water. On that remarkable occasion the flood rose 13 feet in the 24 hours preceding the attainment of its greatest height; and, as we shall presently see that the apex of the curve did not move more than 61 miles per diem, this could only have been a common spring flood at any point 100 miles distant from the top of the wave.

Now, it is not the height at A and B which the river occupies, 100 miles above or below the crest of the curve, that causes the destruction of life and property. It is the top of the wave only, which is sweeping through the valley, buoying up and bearing off every floating object above the line of harmless rise, A B, that is injurious to the works of men.

To control a flood, and render it harmless, we must retain in reservoirs the volume of water which produces that portion of this wave above the line A B, and fills two-thirds of the rectangle, *a* A, *b* B. A rise of twenty-five feet is a flood which, at Wheeling, is shown by experience to cause but little damage. The difference, therefore, between the discharge of the river when at 25 feet, and the actual discharge for whatever period the height rules above 25 feet, is the volume of water to be retained to render the flood entirely harmless.

To make a practical application of the facts, we will take the flood of March, 1841, which, because of its long continuance, would have been the most difficult to control of all the freshets which have occurred within the last eleven years, although there have been instances when the height of the water has been greater for a brief period.

The records, (see Note D,) and Table IV, furnish the following data:

March 24	height,	31 feet	discharge,	17,972,000,000	cubic	feet.
" 25	"	32 "	"	18,760,000,000	"	"
" 26	"	30 "	"	17,088,000,000	"	"
" 27	"	28 "	"	15,322,000,000	"	"
" 28	"	30 "	"	17,088,000,000	"	"
" 29	"	34 "	"	20,624,000,000	"	"
" 30	"	33 "	"	19,700,000,000	"	"
" 31	"	30 "	"	17,088,000,000	"	"
April 1	"	28 "	"	15,322,000,000	"	"
Total discharge during these nine days of high water,				158,964,000,000	"	"

This is the entire volume of water which passed down the river while the height of its surface was more than 25 feet upon the Wheeling bar. But to have kept this flood down to 25 feet all that time, we need only to have retained the excess of the discharge over and above the quantity which would have been vented during the same period, at a 25 feet stage.

The diurnal discharge of the Ohio, when there is 25 feet in the channel, is, by Table IV, 12,752,000,000 cubic feet; and the total discharge for these nine days would then have been, at that depth, 114,768,000,000 cubic feet. The difference between this quantity and the actual discharge is 44,196,000,000 cubic feet; and this is the volume which the reservoirs must be capable of holding, to

enable us to control such a flood as that of 1841, so as to render it harmless at Wheeling.

This volume is just equal to the quantity which the river would discharge in 50 days, when there is a depth of 5 feet in the channel.

If, then, we construct reservoirs upon the Alleghany and Monongahela, or their tributaries, of sufficient capacity to supply the actual discharge for fifty days, at a height of 5 feet, these reservoirs will contain all the water that it is necessary to hold back to protect the upper portions of the valley from the injurious effects of ordinary floods. A reservoir adequate to this object would be four miles square, and very nearly 100 feet deep.

A single dam, no higher than some of those constructed for the canals of this country, may be built on the Alleghany, which will form a lake nearly thirty miles long, with numerous branches, also many miles in extent, and capable of supplying nearly the whole volume of water required for the navigation from that direction, while greatly restraining the floods which proceed from that arm of the Ohio. Equally available sites can be found on the great tributaries of the Monongahela, where reservoirs can be formed without injury to valuable property, competent to supply the deficiency in periods of drought, and capable of controlling the floods in that direction also, when the supply of water is there in excess.

To exercise complete control over all injurious floods will involve a greater outlay than will be required for the effectual improvement of the navigation; but even this can be accomplished by works which will also secure to the navigation a permanent depth of *six feet*, for about the cost of maintaining a ship of the line on a three years' cruise.

The surface velocity of the central current of the Ohio river, at Wheeling, when the average depth in the channel is 35 feet, is very nearly five miles an hour, and the mean velocity of the whole mass of water, four miles an hour. The total movement of the stream, after the river is filled, is therefore very nearly 100 miles a day; and the velocity of a float in the centre of the channel, about 120 miles a day.

These are the results of actual measurements. Yet, though such is the rate of motion of the stream, it can be shown that the movement of the top of the *flood-wave* is a great deal less than this.

The greatest flood of which we have either recorded or traditionary account on the Ohio, is the famous rise of February, 1832, when the river attained a height of 31 feet at Pittsburg, 44½ feet at Wheeling, and 63 feet at Cincinnati, above its summer surface.

This flood reached its highest mark, from place to place along the river, at the following dates:

Pittsburg	February	10.		
Wheeling	"	11	(evening)	88 miles.
Marietta	"	13	(noon)	176 "
Maysville	"	16	(night)	405 "
Cincinnati	"	17	(midnight)	460 "
Louisville	"	21	(morning)	613 "

These dates are chiefly taken from the newspapers of that day—the papers of each city generally recording the time when the water ceased to threaten their respective towns with increasing calamities. From these facts it appears that that remarkable wave travelled from Pittsburg to Cincinnati—a distance computed at 460 miles—in $7\frac{1}{2}$ days; or at the rate of 61 miles a day, or $2\frac{1}{2}$ miles an hour. The rate of the progress of this flood was, therefore, but a fraction more than half as great as the surface velocity of the river in the channel at Wheeling; and but two-thirds of the velocity of the whole mass of water, after it had attained the height of 35 feet.

We do not know, from actual measurement, the precise velocity of the central surface thread of the Ohio at the top of this flood; but computing it from velocities carefully observed up to $31\frac{1}{4}$ feet, it must have been about six miles an hour, or more than twice as great as the actual progress of the flood itself.

This apparent paradox is susceptible of easy and satisfactory explanation. The flood coming from the mountains finds the channel nearly empty as it approaches. The water which rolls past any given point has, therefore, a double duty to perform; first, to fill the channel below, and then to supply the volume which the channel below discharges. The wave is partly spent in filling the empty channel, and is retarded while being replenished from above.

The same circumstance which explains the retardation of the flood-wave, accounts, also, for another fact, observable in the progress of all great freshets—that, while the water is rising, the *drift* leaves the channel, and tends towards the shores; and as the surface falls it recedes from the shores, and seeks the thread of the channel. The swiftest water is near the centre of the river, where there is always the least resistance. The empty stream below is, therefore, first supplied by the central fillet. The foremost water comes down along the centre and at the surface, and flows from the centre towards the shores, to fill up the vacant space. The river, while on the rise, is consequently higher at the centre than at the borders; and the drift descends on the surface, following the lateral current towards the banks.

But, as the water falls, the effect is reversed. The supply first fails above, while the draught still continues from below, and is most rapid at the centre, where there is still the least resistance. The void occasioned by the draught is consequently first produced in the centre, and the water flows in from the shores to supply the void. The drift again obeys the lateral current until it reaches the channel, which, by this excess of the central draught, is depressed below the surface at the shores. The drift floats down the slopes of this depression, and has no power to ascend the plane on either side to regain the shores.

These considerations explain the difficulty, well known to pilots on this river, of keeping the channel on a rising stream. The water being then highest in the centre, the boat is continually drawn towards the banks; while every raftsman knows that it requires no skill to float down the current when the flood is subsiding. This fact is well expressed in the language of an old flat-boat man,

who assured the writer that "he had floated twenty-four hours on a falling river, without once wetting a sweep."

Although, in this paper, the computations have only been made with a view to the reduction of the extreme height of the flood-wave, so as to show that it is quite practicable to render it harmless, there are many interests in society which would be promoted by a further extension of the system, and an ultimate approach toward an equalization of the daily discharge. It is quite reasonable to suppose that, in course of time, all the waters of all the navigable rivers will be required to supply the wants of man and his commerce. Reservoirs may eventually be made, of sufficient capacity to hold *all* the annual excess, and make the daily flow almost entirely uniform. The banks of the Ohio and Mississippi, now broken by the current and lined with fallen trees, ready to be swept by the next freshet into the channel, there to form dangerous snags, may yet, in the course of a very few years, be cultivated and adorned down to the water's edge. In the opinion of the writer, the grass will hereafter grow luxuriantly along the caving banks; all material fluctuations of the waters will be prevented, and the level of the river's surface will become nearly stationary. Grounds, which are now frequently inundated and valueless, will be tilled and subdued; the sand-bars will be permanently covered, and, under an uniform regimen of the stream, will probably cease to be produced. The channels will become stationary. The wharves will be built as the wharves on tide water, with little, if any, reference to the fluctuations of the surface. The lower streets of all the river towns, no longer exposed to inundations, will acquire new value. The turbid waters will be arrested in the upper pools, and the Ohio first, and ultimately the Missouri and Mississippi, will be made to flow forever with a constant, deep, and limpid stream. The ice will be swept off as it forms, and neither cold nor droughts will longer be suffered injuriously to affect the navigation. The Ocean steamers will not then be confined to tide waters, but will be able safely to ascend the living streams to sea ports on their borders, and the extent of the inland navigation will be limited only by the limit to the water which is supplied by the atmosphere.

All this may be accomplished on the Ohio *for about the cost of three or four ships of the line.* The great and only difficulty is to overcome the cold incredulity of the public, so as to induce those in power to grant a sufficient appropriation for the completion of the first two reservoirs. This once accomplished, and a single practical demonstration made, it will be difficult to convince the future engineer that a thing so clear and palpable could ever be doubted.

As an effort of art, the work of controlling the floods of the great rivers of the Mississippi valley, will never compare with the labors of men in other departments of practical science. More money has been laid out on three miles of railroad than would be needed to maintain the waters of the Ohio within two feet of an uniform height throughout the year; to add a length of several hundred miles to the river navigation of the country, and render more than two

thousand miles of precarious navigation permanent and certain. The same reservoir that keeps back the excess of water from the tributary, keeps it back also from the recipient stream; the same supply that maintains the navigation of the tributary, also improves that of the recipient; and the same reservoir that serves to maintain the navigation of both tributary and recipient, serves, of necessity, to protect both from overflow.

These things will be effected, not by main force, but by skill. The rain gauge will indicate the approaching danger from the summits of the distant mountains; the telegraph will announce the fact at the flood-gates, and the whole may thus be controlled by the previsions of science. In fact, the desired effect can be produced by a few dams in the mountain gorges, and the constant attention of some twenty men.

OF THE IMPROVEMENT OF THE OHIO.

It has become fashionable to depreciate the importance of river navigation, as a thing shortly to give way to the great improvements of the age—the railroad and locomotive. But if we reflect that the cost of transporting a barrel of flour from Pittsburg to New Orleans, 2,050 miles, by steamboats, is now often but 50 cents, while the lowest price at which that article can be conveyed by railroads, with any profit, is three cents per ton per mile, or at the rate of $6 per barrel from Pittsburg to New Orleans, we shall better appreciate the importance of the Ohio and Mississippi rivers to the agricultural and commercial interests of the country.

The present charge for a cabin passenger on the same route, with all the comforts of a good boat, is but $15, for a distance of more than 2000 miles—and that sum covers his living by the way. The corresponding railroad charge would be from $60 to $80, and the traveller would pay his board on the journey.

The discussion of this subject is quite foreign to the object of the present paper; yet, we ought never to forget, when considering the value of the western rivers, that the great cities of Pittsburg, Cincinnati, Louisville, St. Louis, and New Orleans, and scores of less note, all owe their origin, growth, and present prosperity, to the river trade. And until such emporiums of trade are built up and maintained by some artificial cause, we have no right to despise the channels that have created the wealth and commercial activity that is concentrated in these. Yet, these great cities, prosperous as they are, and rapid as has been their growth, are but isolated though prominent evidences of the general vigor and prosperity of the vast region watered by these great streams.

The Mississippi valley, with all its depth of soil, and forests of timber and mineral riches, would be a comparative waste, if deprived of the great rivers

which penetrate by their branches all its recesses, facilitate its domestic exchanges, and bear all its products to the Ocean.

In truth, the internal navigation of the country must be always regarded as the arterial circulation of its wealth and commerce; and whatever will improve that navigation, deserves the care and patronage of the people and those to whom the people confide the protection of their interests.

It has been estimated by Col. Long that the western rivers afford a development of 16,674 miles of steamboat navigation;* while the commerce of these rivers, for the year 1843, according to the estimate submitted to the Senate by Mr. Barrow, possessed a value of more than $220,000,000.†

The navigation of nearly all the streams bearing this vast and rapidly increasing commerce is interrupted during *more than one third of the year* by the want of water, or by ice, which accumulates to an injurious extent because of the want of water. This interruption is equivalent in its effects to an annual tax upon the industry of the country equal to one-third the yearly expense of maintaining all the steamboats that are subject to the detention, together with the value of the delay upon all the property that is exposed and detained, and that of the deterioration and early destruction of all the boats that are compelled to run when there is too little water to float them safely.

The number of boats navigating the western rivers is, probably, at this time, not less than 1,000; and it is estimated, partly from accurate official data, and partly from conjectural data based upon official returns, that the total loss from wrecks of steamboats on these waters, for the year 1848 alone, amounted to $2,000,000.

There are no data for determining the loss consequent upon the detention of the boats; but as the delay falls chiefly upon the largest steamers, which are always first arrested, the loss must greatly exceed the actual cost of maintaining one-third of all the boats in use on the western waters. But if this item be only equal to the cost of maintaining and running 750 boats one-third of the year, or 250 boats of average value the whole year, it will amount to not less than $3,000,000 per annum, over and above the loss now sustained on the property conveyed, and that on the commerce which cannot be conveyed.

By upholding the draught in the channel, the cost of transportation—which now fluctuates between 8 cents and $1.75 per hundred pounds from Pittsburg to Cincinnati—could be maintained with profit to the carrier at about the lowest present charge, and the whole business of the valley would experience a corresponding increase consequent on the reduction of the cost of freight. A vastly increased tonnage would necessarily be conveyed at greatly reduced rates. The business of the transporter would become more certain and more stable; lines would be established to act with regularity and despatch, and every department of agriculture and commerce, through all the

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* Report of the Commissioner of Patents, of December 30, 1848.

† Report of the Committee of Commerce, (Senate,) February 9, 1843.

wide valley, would feel the effect of an increase of speed, certainty of delivery, and reduction of the cost of conveyance.

It is scarcely to be doubted that the maintenance of a depth of 5 feet in the Ohio alone, at all seasons, would save the country from an *annual* tax upon its present business of five millions of dollars, or about eight times the sum necessary to produce the saving.

The value and importance of this navigation, and that of the growing interests dependent upon it, demand an improvement worthy of this Government, and worthy the character of a river, navigable in good water a distance of 1,200 miles, and bearing by far the greater portion of an annual commerce already valued at $220,000,000; and no improvement would be worthy of this trade and this position, that will not permit the largest of the New Orleans steamers to ascend the Ohio, without fear of impediment at all seasons, to Cincinnati and Pittsburg. (See Note B.)

All the efforts which have yet been made to improve the great rivers of this country have proceeded upon a plan of gaining depth without an increase of water. There is, however, no better extensive inland navigation in the world, than that afforded by the natural bosom of the Ohio when well supplied with water; and the navigation never fails but when the water fails. The simple remedy, therefore, is to supply the deficiency which produces the evil. (See Note C.)

If an engineer had prepared a plan of improvement, contemplating the excavation of *a canal as large as the Ohio*—a thousand miles long, a thousand feet wide, and seven feet deep—and the excavation of reservoirs capacious enough to supply it with water, it would be easy to demonstrate that such a work is feasible, and that the cost might not be greater than the actual value of the river which now connects the seaboard cities with the Mississippi, and floats the commerce of ten or twelve of the States of this Union. The practicability of such a canal could be easily demonstrated, for it involves plans precisely analogous to those of works that have been already executed. Such an enterprise might even be considered worthy of the destinies of the American people, and in accordance with the spirit of the age in which we live.

But the writer has no such magnificent effort to propose—no achievement, even, to compare with the great works already accomplished by the private enterprise of the country.

It is not proposed to dig a canal, or to form a reservoir. Nature has already prepared the Ohio river, and excavated for it a channel, capacious enough for the largest steamers. Nature has adjusted its bed so admirably, that no locks are needed to overcome its fall; no dams to break its current; no aqueducts to carry it over valleys; no engines to provide it with water, or labor to excavate the lakes which are needed to hold a reserve supply.

The canal is dug, and the lakes are excavated, and the water is abundantly supplied from the clouds. All that is left for the ingenuity and enterprise of man to accomplish, to perfect the navigation, is to build a few stone walls

across some of the tributary streams, and hold back a small portion of the surplus water in the lakes that are there already formed, and then provide common sluice gates to emit that water into the channel when it is needed.

This is all that is necessary for the spirit of this and future ages to accomplish, to obtain a perennial and unbroken navigation of nearly 1,000 miles along the Ohio, and many hundred miles along its tributary valleys.

The observations which have been recorded in the foregoing pages will serve to teach us how to proceed in thus improving the navigation, cheaply and permanently, to any practicable extent.

These observations show that, to supply all the water necessary to produce a depth of $2\frac{1}{2}$ feet on the bar at Wheeling—supposing that the natural supply had failed for a brief period entirely—would require a reservoir capable of furnishing 310,000,000 cubic feet per diem. But looking over the records of the last eleven years, we meet with but one season—that of 1838—when a depth of less than $2\frac{1}{2}$ feet continued for a longer period than 65 days. That was truly a remarkable year—well remembered by every engineer then occupied with works in any manner depending on the supply of rivers. (See Record, Note D.)

Taking that season as a guide, we find that to have made up the deficiency of the natural flow of the Ohio, and furnish the excess needed to maintain the depth at $2\frac{1}{2}$ feet, would have required an average augmentation of the natural daily discharge of the stream of 100,000,000 cubic feet, or a total supply for the 65 days of 6,500,000,000 cubic feet.

Now, if we construct a dam across the Alleghany river, near Franklin, no higher than one of those on the Lehigh—58 feet—and provided with a lock for the accommodation of the upper trade, as is usual at the dams across all navigable rivers, we shall observe by the fall of the Alleghany, exhibited in the profile, Fig. 2, that this dam will create a reservoir about 25 miles in length, having a depth of 58 feet at one extreme, and reduced to the ordinary depth of the river at the other. But it would do more. It would set back the water many miles up numerous tributary streams which empty into the Alleghany along these 25 miles, and up all the ravines and lateral branches of these tributary streams. There are many artificial pools on the navigable rivers of this country, from 15 to 20 miles in length. The dam near the Grand rapids on the Wabash has formed a pond 17 miles long. The dam at the Horse-shoe bend, on Kentucky river, has created one 27 miles long, and that at Cedar ripple, on the same stream, has produced a pool of 23 miles. Dams of greater height have been built, and lakes of greater length have been created, on many of the rivers of this country, than will be required by the improvement here proposed; though no doubt it will be found to be good economy to construct higher dams and locks of greater lift, and form reservoirs of greater capacity, in carrying out this system to its full extent, than have yet been demanded by existing works. This course may, and probably will, be dictated by true economy; but it is not at all necessary to success, nor intended to be recommended in the first steps.

The valley of the Upper Alleghany is, from hill to hill, about one-third of a mile in width. A reservoir, 25 miles in length, would, therefore, cover an area of some 8 or 9 square miles along the principal valley, and much more than that in its lateral branches. Such a dam as is here spoken of—from 55 to 60 feet in height—would probably form a lake covering from 16 to 18 square miles, with an average depth of near 30 feet, and containing more than 12,000,000,000 cubic feet of water. This is nearly double the quantity which was ascertained above to have been requisite to supply a depth of 2½ feet during the whole of the summer of 1838, the season of greatest drought ever known west of the Alleghany range.

Now, we have already seen that the whole volume of water constituting the injurious portion of the flood of 1841 could have been retained in reservoirs capable of holding 44,000,000,000 cubic feet. It follows, then, that we should need but four dams, such as are here described, less than 60 feet high, to secure the valley of the upper Ohio against all destructive floods; and these same dams, as already shown, would be capable of supplying the navigation with sufficient water for boats of 5 feet draught during a period of 60 days, if the natural discharge should fail entirely.

But, though the Ohio never ceases entirely to send water to the Ocean, it will be seen, by reference to Note D, in the Appendix, that, during the memorable drought of 1838, there was a period of 120 consecutive days when the depth on the bar at Wheeling was less than 5 feet. The actual average daily discharge during these 120 days, computed by the formula given in this paper, was about 220,000,000 cubic feet. The daily discharge, when there is 5 feet on the bar, has been found to be 864,000,000 cubic feet. The difference between these quantities is 644,000,000, which is the volume that should have been furnished daily for 120 days, in 1838, to have secured a depth of 5 feet throughout that year.

Reservoirs capable of furnishing this volume must possess a capacity of 77,000,000,000 cubic feet. But this was a period of unexampled suffering from drought; and an application of the facts furnished by the tables and records in these pages shows that a supply which would have been sufficient to secure a depth of five feet in 1838, would have secured full *six feet* in any ordinary season.

We shall then require three or four high dams upon the Alleghany and Monongahela, or an equivalent number upon other tributaries of the Ohio, to insure, with this single known exception, a perpetual navigation for boats of 5 feet draught.

It is not appropriate in this place to enter into any detailed estimate of the cost, or description of the mode of constructing, such dams. It may be said, however, that they should be formed of massive masonry, set in hydraulic cement, and built more with reference to the part they are to perform in advancing the commercial prosperity of the country, than with a view to stinted economy. Yet, formed as monuments of the art and enterprise of the age, it is

not probable that the cost of each dam, with its lock, valves, syphons, and appurtenances, will exceed $200,000 or $250,000.

It has been the duty of the writer, at former periods, to conduct surveys along a considerable portion of the Upper Alleghany, and the whole of the Great Kanawha, and to become familiar with the character of the Monongahela as far as it is susceptible of improvement. Aided by this personal knowledge and the facts acquired in the present investigation, he hazards the opinion that less than a million and a quarter of dollars will suffice to supply the Ohio with a depth sufficient for boats of 5 feet draught; to carry an open and permanent river navigation up the Alleghany to Franklin, and a slack water navigation, during three-fourths of the year, from Franklin to the line of the Erie railroad in New York; improve the navigation of the Monongahela into Virginia, and extend that of the Kanawha 70 or 80 miles above Point Pleasant—supplying water powers of unrivalled capacity and permanence, on numerous lines of steamboat navigation, and curbing most essentially the destructive power of the floods.

Viewing the insignificant cost for which about 1,400 miles of river navigation may thus be rendered permanently available—without reference to the incidental advantages that will flow from the work—it may well be doubted whether there is, in the whole circle of contemplated public improvements, a projected enterprise which more seriously demands the care and consideration of those who are charged with the protection of the public interests.

The difficulty which the mind first encounters in contemplating this proposition arises from the apparent immensity of the mass of waters to be dealt with. But this is only a speculation. The quantity has been measured, and found to be easily attainable and perfectly manageable.

The total discharge of the Ohio, in ordinary low water, is but 6,000,000 cubic feet per hour. A pipe no larger than one of those used for conveying the water of the Croton water-works—or three feet in diameter—will discharge very nearly 1,000,000 cubic feet per hour under a head of 60 feet. Six such pipes, then, placed in a dam only 60 feet high, and provided with proper valves, would emit water enough to double the quantity flowing down the Ohio at its usual summer stage. And if there were three such dams on different streams, and 12 pipes in each, and one man to superintend each dam, and obey the telegraphic signal to open or close the valves—or an equipment equal to three dams no higher than have been already built in this country, and 36 pipes equal in diameter to the mains in Broadway, and three men to manage the whole—the quantity of water could be increased six-fold, and the navigation could be maintained above 5 feet during all ordinary droughts. At the same time, such is, happily, the form of many of the western valleys, that dams of double this height can be often erected without injury to any appreciable amount of property, improved or susceptible of improvement.

WATER POWER.

The reservoirs which it is proposed to form primarily for the improvement of the navigation, will be productive of many incidental benefits, apart from their influence upon the floods and the commerce of the country.

In the progress of society the power furnished by the rivers, limited to their low-water supply, often becomes inadequate to the wants of the population on their borders. This power may be vastly increased by the creation of small lakes to retain the surplus which is ordinarily wasted, until the natural flow becomes insufficient, even where the navigation forms no part of the ultimate object.

In the far West there are great rivers which send their periodic floods to the Gulf of Mexico, through plains of vast extent, which are waste and sterile for want of water. There is no navigation because the streams are dry. The lands are unproductive, because, at certain seasons, there is no rain. Yet, the floods of winter, if properly controlled, would suffice to irrigate the soil, extend navigation far into the interior, furnish power to manufacture the products which they would create, and thus spread wider the area of civilization.

The water need not be discharged directly at the site of the dam, and suffered to spend its power in producing the discharge; but it may be led off, by appropriate mains, to suitable ground for manufacturing establishments, and be there applied to useful machinery. In its descent it may be arrested from point to point, brought many times into service, and finally sent on its last mission of good into the stream which it will make navigable, and capable of conveying the products which it has already aided to manufacture.

The water contained in the reservoirs upon the Alleghany could be advantageously used for the manufacture of all the lumber sent down that stream; and these reservoirs, ultimately extending navigation along that river into the State of New York, and connecting the navigable waters of the Mississippi with those of the Great Lakes and the Atlantic, by the Erie railroad and its branches, will be needed, in the progress of time, to furnish the power for the manufacture of the products of a vast area along the Ohio, as well as around the northern borders.

Thus a small portion of the cost of the artificial fountains of a single chateau would, in this country, enable us to control the floods of a river surpassing in grandeur the noblest stream of Europe—maintain, constantly, an uninterrupted navigation of 1,300 miles—create a water power sufficient to convert into useful forms the products of all the country watered by the tributary streams, and give rise to cities which it would incidentally adorn with fountains, such as the wealth of the "Great Monarch" of the last century could not purchase.

OF THE PROPER APPLICATION OF RESERVOIRS TO THE IMPROVEMENT OF RIVERS.

It is not intended to recommend the application of this mode of improvement to all streams. It is only those rivers, or parts of rivers, on which the imperfections of the channel are caused essentially by a deficiency of water, in seasons of drought, and not by the rapidity of their fall, or obstructions in their beds, that are susceptible of this mode of improvement. Rivers which, like the Ohio, Alleghany, Cumberland, and Tennessee, are always navigable when there is sufficient water in their channels to float the boats freely, but of which the navigation fails because the supply of water fails, and on which lakes may be formed at small expense, without injury to valuable property or to the salubrity of the country—such rivers as these can be best, most cheaply, permanently, and effectually improved, by collecting a portion of the waters which are wasted in producing floods, and holding them in store for the season when the sources of supply fail to render their customary tribute to the channel.

Such are essentially the characteristics of all the great rivers of the Mississippi valley.

Many of these streams rise in the mountain ridges, and flow great distances through depressions parallel with the range in which they originate. Those which descend from the Alleghany break through the subordinate ranges of Laurel Hill, Greenbriar, Big Sewell, and other parallel and analogous formations, where many gorges are presented easy to dam up, and where the lakes to be formed will lie enclosed within a rim of rock, which will insure a purity equal to that of the waters of Erie or Ontario. Tens, and perhaps hundreds, of such sites exist in the valleys of the Alleghany, Monongahela, Great Kanawha, and their tributaries; and, indeed, along all the rivers that flow from the mountains on either slope of the great dividing ridge.

It is not to be maintained that the water will become less salubrious because it is confined. The lakes which it is proposed to form are in all respects analogous to the great fresh-water lakes of the globe, which are provided with outlets to the Ocean, through which the water is slowly discharged, but, nevertheless, so adjusted as to retain the same water for a long series of years.

The salubrity of the fluid is not impaired by this exposure. The Falls of Niagara probably do not vent the volume of water which is contained in Lake Erie more than once in six or eight years; and it is certain that the contents of all the upper lakes would not pass over the cateract in half a century.

Nature relies for effecting the change which is forever taking place in great bodies of fresh water, almost exclusively on the process of evaporation; and

has provided that the fluid shall be thoroughly exposed to sun, and light, and air, by the agitation of its surface when in volume, and by its suspension in the clouds after its evaporation.

The healthfulness of the country cannot be impaired by the formation of artificial reservoirs in all respects analogous to those of Nature, liable to be drained off, to some extent, more than once in every year. They need not cover vegetable matter in sufficient quantity to cause apprehension from the effect of its decomposition. These reservoirs are not intended to be wholly exhausted; and need only to be reduced at the surface, so as to lay bare a portion of their rocky borders.

But the salubrity of rivers, when no longer subject to become dry, and have their sands and vegetable deposits exposed to the summer's sun, must necessarily be increased; for the same experience which teaches that large masses of fresh water, existing as lakes, are salubrious, also teaches that shallow, stagnant pools, such as are found in the place of an exhausted river, are deleterious to health.

It is difficult to imagine a serious objection to the improvement of this great natural system of inland navigation, by a method which accomplishes so much for an outlay so small—by a plan which places no incidental impediment in the way of trade, and the application of which is limited to no State or section of the Union.

From the base of the Rocky Mountains to the base of the Alleghany, there is not a great river or navigable tributary that may not be benefitted by this process; while on the eastern slope of the dividing range there are numerous rivers flowing into the Atlantic which have been improved by other means, and which must ultimately be subjected to this treatment, and relieved of the dams by which they are now obstructed.

The North Branch of the Susquehanna may be easily made navigable, from its mouth into the State of New York, for a convenient class of steamboats, by this simple expedient; and there are several rivers in Virginia, which, for an insignificant cost, may probably thus be supplied with abundant water for a permanent navigation.

The personal observation of the writer does not extend to the great rivers of the southern States. But the elevations of their surfaces above tide, from point to point, seem to indicate that they are even more susceptible of the application of this method of improvement than those further north; while the Cumberland and Tennessee, and the rivers of Kentucky, possess all the essential characteristics of the Ohio, and will always afford a good navigation for steamboats whenever they are adequately supplied with water.

Further west the field of valuable improvement is immense. Probably two thousand miles of precarious navigation on the Missouri alone, may be rendered permanent and safe by a few dams constructed upon the great tributaries above the mouth of the Yellow Stone; and, as civilization is carried by steam into those distant regions, it is reasonable to suppose that the same incidental

advantages to society will be experienced there, which, it can be shown, are certain to follow the application of this system on the Ohio.

It is not asserting more than the measurements presented in this paper will justify, when it is maintained that it is entirely in the power of man to control all the waters of the Mississippi and Missouri, and compel every river to flow with an even current, from its source in the Alleghany or Rocky Mountains, to its home in the Ocean, forever free from the hurtful effects of floods and droughts.

The writer can scarcely hope immediately to remove the suspicion and distrust with which the first announcement of his plan was met by the public; but yet he believes that the period is past when prejudice or doubt can long resist the force of demonstration. When, in a former age, it was proposed in Spain to unite two rivers by a navigable canal, a commission of the Inquisition decided against the project, on the broad ground that, if it had been the Will of God that those rivers should be united, they would have been joined in their creation. The decision was in conformity with the spirit of the age and the people, and was doubtless dictated by honest views of piety and right.

But times have changed, and men are learning to look upon this Earth and all it contains as a gift from God to the beings of his creation, to be used, explored, studied, and improved.

The waters are not the least of these bounteous gifts. But it does not follow, because they are supplied in abundance, they were intended forever to be wasted. It is more in unison with what is known of the original design to conclude that the apparent excess was intended for many useful purposes; to be collected for the benefit of the parched earth; for the power that it affords; for the transportation of the products which it serves to increase and prepare; and not forever to burst, periodically, in a wave of destruction upon man and his works.

The writer takes this occasion to express his obligation to his friend, I. Dickinson, civil engineer, for much valuable aid in making the observations recorded in Table III. of this memoir.

NOTES.

NOTE A.

The average volume of water annually flowing down the Ohio is shown in the text to be 835,000,000,000 cubic feet. This volume would fill a lake 100 feet deep and $17\frac{1}{3}$ miles square.

To have regulated the supply of the river in 1848, so as to have kept the depth on the bar at Wheeling uniform throughout the year, would have required reservoirs capable of holding 240,000,000,000 cubic feet, which is equivalent to a single lake 100 feet deep and $9\frac{1}{8}$ miles square.

There is no difficulty, on any of the principal tributaries of the Upper Ohio, in obtaining reservoirs capable of holding from twelve to twenty thousand millions of cubic feet. It can scarcely be doubted that twelve or fifteen sites for dams may be selected capacious enough to hold all the excess of water, and equalize the annual discharge so nearly, that the depth may be kept within a very few feet of an invariable height.

NOTE B.

It is by no means improbable that a sufficient depth of water may be constantly maintained in the Ohio, above Louisville, to permit boats to *ascend the Falls* at all times, and thus supersede the necessity of a new and enlarged canal. But the measurements now in the possession of the writer having been all made at Wheeling, and applied to the records kept at that point, he cannot express a positive opinion upon this important question. The results, as far as they go, point to an equalization of the daily discharge of the Ohio as, possibly, the cheapest mode of improving the Falls; making that work an incidental consequence of a systematic and adequate improvement of the general navigation of this river and its tributaries.

NOTE C.

Although there has never been any attempt made, or proposition offered, to supply the channels of great navigable rivers from stores of water held in reserve, as is here contemplated, yet experiments have been made, and expedients resorted to, in various practical operations, so analogous to this method, that they ought to have led to some such suggestion.

It has long been the practice on some of the smaller rivers of Europe, to erect moveable dams, which would retain the water, and overflow the shoals above the dams; and when the boats have passed the upper shoals, the dam is lowered, and the boats allowed to descend with the water of the pool; and keeping on the top of the wave, they are thus enabled to pass the shoals below.

A similar expedient has been long in use on Oil creek, and some of the other tributaries of the Alleghany river. The lumber men there frequently send their lumber from the smaller tributaries into the larger, by opening the sluices of their mill dams, and creating a flood sufficient to float their rafts into deeper water.

The Lehigh Navigation Company of Pennsylvania were compelled, for many years before the completion of their improvement, to send their arks, loaded with coal, down the channel of the Lehigh by the same process. The fall of the river was rapid, and the supply of water very insufficient. The arks were floated through the pools formed by the dams, and passed by locks into the channels below. The water was then drawn through sluices from the pool above the dam, and the coal boats were borne on the top of the wave over the shoals in the channel.

The Schuylkill Navigation Company have been in the practice for years, when their boats have grounded in the pools from want of water, of increasing the depth by drawing water through sluice gates in the dams above. Even the small dams on that river are so supplied with gates for venting the water, that the stream is kept in complete control during the summer season. By opening the gates the pond above is emptied, and a small flood is produced below. By closing the gates, the supply furnished by the river is held back for many hours, while the empty pool is being replenished. During that time no water reaches the channel below.

NOTE D.—RECORD OF THE DAILY HEIGHT OF WATER ON THE WHEELING BAR FROM 1838 TO 1842, INCLUDING BOTH YEARS.

RECORD FOR THE YEAR 1838.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	–	–	–	11	17	16	6½	2⅓	1⅔	1	1½	3
2	–	–	–	9	15	14	7	2½	1⅔	1	1½	3
3	–	–	–	8	15	12	6½	2½	1½	1	1½	3
4	–	–	–	7½	17	10	6	2½	1½	1	1½	3
5	–	–	–	7	19	9	6	2¼	1⅜	1	2½	3
6	–	–	–	6½	24	9	5½	2¼	1⅓	1	4	2⅔
7	–	–	–	6½	31	9	5½	2⅛	1¼	1	6	3
8	–	–	–	6	29	9	5	2	1¼	1	8	3
9	–	–	–	7	26	12	4½	2	1¼	1	9	3
10	–	–	18	8	20	10	4	1⅞	1⅛	1	9	
11	–	–	13	11	16	8	5⅔	2⅛	1¼	1	9	
12	–	–	13	13	14	8	3½	2⅓	1⅛	1	8	
13	–	–	15	10	12	7	3½	2⅓	1⅛	1	7	
14	–	–	17	11	10	7	3½	3	1⅛	1	6	
15	–	–	20	10	9	6	3¼	3	1⅛	1	5	
16	–	–	22	9	8	7	3	3½	1⅛	1⅞	5	
17	–	–	22	9	8	7	3	3⅓	1⅛	1	5	
18	–	–	20	14	15	8	3	3⅛	1⅓	1½	7	
19	–	–	16	14	18	8	2⅞	2¾	1	2¼	9	
20	–	–	16	15	17	8	2⅔	2¾	1	2¼	11	
21	–	–	17	14	15	8	2½	3½	1	2⅛	9	
22	–	–	22	13	13	7	2½	3¼	1	2⅛	8	
23	–	–	25	12	13	7	2⅓	2⅞	1	2⅛	7	
24	–	–	24	10	18	8	2⅓	2⅔	1	2⅛	6	
25	–	–	26	15	22	9	2⅓	2⅓	1	2	5	
26	–	–	25	16	20	10	2⅓	2¼	1	1⅞	4½	
27	–	–	24	16	18	9	2⅓	2⅛	0⅞	1⅔	4	
28	–	–	20	15	15	8	2⅓	2	0⅞	1⅔	4	
29	–	–	16	15	15	7	2¼	1⅞	0⅞	1⅔	3½	
30	–	–	14	16	16	6½	2¼	1⅔	0⅞	1½	3	
31	–	–	13	–	16	–	2⅓	1⅝	–	1½	–	

RECORD FOR THE YEAR 1839.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	–	–	16	11	5½	12	11	7	3⅛	3	1⅜	5
2	–	–	15	10	7	9	9	7	2¾	3	1⅜	5
3	–	–	14	10	9	8	8	7	2½	2⅞	1⅜	5
4	–	–	14	9	12	8	7	6	2⅓	2⅞	1⅜	5
5	–	–	13	9	13	8	6	6	2¼	2¾	1⅜	5
6	–	–	12	8	11	7	6	5	2¼	2⅔	1½	5½
7	–	–	11	7	10	10	5½	4¼	2½	2⅜	1⅝	5½
8	–	–	10	7	9	12	5	4	3	2⅓	1¾	5½
9	–	–	10	7	8	10	4½	3¾	5½	2¼	2	5½
10	–	–	11	6	7	10	4	3½	7	2⅛	2½	5½
11	–	–	11	6	6	9	3⅔	3¼	11	2	2½	5
12	8	10	10	5⅔	5½	8	3½	3	9	1⅞	2⅓	5
13	13	8	9	6	5½	13	3⅜	3⅓	7	1⅞	2	5
14	22	7	8	10	5	16	3⅓	3⅓	5½	1⅞	2	5
15	21	6	9	11	5	22	3	3	4¾	1⅞	2⅓	4½
16	18	5½	10	9	5½	23	2¾	2⅔	3¾	1⅞	2¾	4½
17	16	5	10	8	6	18	2½	2½	3¾	1⅞	3	4½
18	13	4⅔	9	7	6	15	2⅓	2⅓	3½	1⅞	4	4
19	11	4⅓	10	7	7	12	2¼	2¼	3⅓	1⅞	5½	4
20	9	4⅓	10	6	6⅔	10	2⅛	2⅛	3¼	1⅞	6	4
21	8	4	14	6	6	8	2⅛	2⅛	6	1¾	5½	3¼
22	7	4	17	5½	6	8	2⅛	2⅛	6	1⅔	5	3½
23	6	4⅛	17	5⅓	5½	7	2⅝	2⅝	5½	1⅔	5	3½
24	5½	5½	15	5⅓	7½	6	2⅓	2⅓	5	1⅔	4½	3
25	5	8	13	5	9	6	2⅔	2⅔	4⅛	1⅔	4½	3
26	–	13	12	5	10	5½	2⅔	2⅔	4¾	1⅝	4½	3
27	–	17	11	4¾	10	5½	3⅓	3⅓	3⅜	1⅝	5	3
28	–	19	10	4½	10	5½	5⅔	5⅔	3¼	1½	5½	3
29	–	–	9	4½	15	6	3⅔	3⅔	3⅛	1⅜	5½	
30	–	–	10	4¾	16	12	3¾	3⅔	3⅛	1⅜	5	
31	–	–	10	–	15	–	3½	3½	–	1⅜		

RECORD FOR THE YEAR 1840.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	–	20	17	24	23	4½	6	2⅛	3	2	10	6
2	–	24	15	20	28	4½	5½	2⅛	3½	2	11	6
3	–	28	13	18	26	4½	5	2	4	2⅓	10	6
4	–	20	14	16	24	5	4¼	2	4	3	9	5½
5	–	16	13	16	22	6	3¾	2	3½	4	8	5½
6	–	12	12	14	20	7½	3¼	2⅛	3⅓	4	6½	5
7	–	9	11	11	18	7	3	2⅛	3⅛	2	6½	5
8	–	9	10	9	15	6	3	2⅓	2⅞	4½	6	4½
9	–	15	9	8	16	6	3	2⅓	2⅔	4	5	4¼
10	–	28	8	8	17	7	2¾	2¼	2½	3¾	4⅔	4½
11	–	38	7	7	19	7	2⅝	2¼	2⅓	3⅓	4⅛	5
12	–	34	7	7	20	6	2½	2⅛	2⅛	3¼	5	5½
13	–	28	6	7	18	5	2⅓	2¼	2	3	7	6
14	–	20	6	7	16	4½	2⅓	2⅓	1⅛	2¾	6	8
15	–	18	6	8	12	4	2¼	2¼	1⅛	2¾	5½	10
16	–	17	5½	8	10	5⅔	3¼	2¼	1⅛	3	6½	11
17	–	16	5½	8	9	3⅜	2¼	2½	1⅛	3	5	10
18	–	15	5½	7	8	3¼	2⅛	2¾	1⅛	2¾	5	9
19	–	14	6	7	8	3	2⅛	3⅛	1⅞	2¾	5	8
20	–	14	7	7	7	2⅞	2⅛	2⅜	1¾	3	5½	7
21	–	13	7	6	7	2¾	2⅛	2⅜	1¾	3	5½	8
22	7	20	7	6	6	5½	3	2	2⅓	4½	7	7
23	8	28	8	6	5½	3	2	2⅓	2¼	5	7	6
24	9	33	8	7	5½	3½	1	2¼	2⅓	5½	8	5
25	10	36	8	12	6	3	1	2	2⅔	5½	11	5
26	10	36	11	15	6	3	2	2	2½	5⅓	10	4½
27	10	24	14	12	6	3	1	2⅔	2⅓	5	8	4½
28	10	22	12	12	6	3½	2	4	2	4½	8	4¼
29	12	20	16	13	5	5	2	4	2	4½	8	4
30	14	–	17	17	4½	5½	2	5½	2	6	7	3¾
31	18	–	21	–	4½	–	2	3	–	8	–	3¾

RECORD FOR THE YEAR 1841.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	–	14	4½	28	15	5	5	2	1¼	3	3	7
2	–	12	5	24	18	4½	4¾	2	1¼	3	3	6
3	–	13	6	20	18	4½	4½	3	1¼	2⅔	3	5½
4	–	13	7	18	16	4¼	4	2¾	1¼	2⅔	3	5½
5	–	11	7	17	14	4	3	2¾	1¼	2⅛	3	6
6	–	9	7	15	12	4	5½	2¾	1	2⅓	3	11
7	–	8	6	15	10	3½	3½	2⅔	1	2	3	11
8	–	7	6	15	14	3⅓	3½	2	3	2	3	10
9	–	7	6	16	14	3⅓	3½	2	1	1⅞	2⅞	9
10	22	6	5½	16	15	3½	3	2	1	1¾	2¾	8
11	20	5	5½	14	16	3½	3½	2	2	1½	2¾	11
12	17	4	5½	14	18	3½	3	2	1	1¾	2¾	20
13	17	4	5½	14	20	3⅓	3	1⅔	1	1¾	4	24
14	17	4	5½	13	18	3⅛	2⅞	1⅔	1	1¾	4¼	22
15	16	4	6	13	16	2⅞	2⅝	1⅔	1	1¾	4½	19
16	16	4	7	12	12	2⅞	2½	1⅝	1	2	4½	16
17	17	4	6	12	10	3	2⅓	1⅝	1	3	4¼	16
18	22	4	6	13	8	3	2⅓	1½	1	3	4	14
19	19	4	5½	12	8	3¼	2½	1⅜	1⅛	3	4	13
20	18	4	5½	15	7	4	2⅓	1⅓	1¼	2½	4	12
21	15	4½	7	13	6	6	2⅓	1⅓	1¼	2½	3⅞	11
22	12	4½	8	11	6	6	2⅓	1⅝	1⅓	2⅓	3⅔	11
23	10	4	21	11	5⅔	5	2	1½	1⅓	2⅓	4	17
24	9	4	31	10	5½	5	1⅞	1½	1⅓	2¼	5	20
25	9	4	32	10	5¾	5	2¾	1⅜	1⅓	2¼	8	18
26	8	4	30	10	5¾	6	2¾	1⅜	1⅓	2⅜	11	17
27	8	4	28	9	6	5½	2¾	1⅜	1⅓	3	10	15
28	7	4½	30	8	6	5½	2¾	1⅓	1⅓	3½	9	10
29	8	–	34	10	6	5	2¾	1⅓	1¾	3¼	8	9
30	8	–	33	12	5½	6	2⅔	1⅓	2½	3	8	8
31	10	–	30	–	5½	–	2	1¼	–	3	–	8

RECORD FOR THE YEAR 1842.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	7	8	8	9	8	6	7	3	9	$3\frac{1}{2}$	5	
2	$6\frac{1}{2}$	10	9	8	8	$5\frac{1}{2}$	$5\frac{1}{2}$	3	7	$3\frac{1}{3}$	$4\frac{1}{3}$	
3	6	11	10	$7\frac{1}{2}$	8	5	5	4	6	3	$4\frac{1}{4}$	
4	$5\frac{1}{2}$	18	12	8	10	5	6	4	7	3	4	
5	5	28	18	12	19	5	7	$3\frac{1}{3}$	7	$2\frac{7}{8}$	$3\frac{7}{8}$	$5\frac{1}{3}$
6	5	31	26	12	17	$4\frac{3}{8}$	8	$3\frac{3}{8}$	8	$2\frac{7}{8}$	$3\frac{7}{8}$	$9\frac{5}{8}$
7	12	28	25	15	12	$4\frac{3}{8}$	9	$3\frac{5}{8}$	10	$2\frac{5}{8}$	$3\frac{5}{8}$	14
8	16	24	23	17	9	$4\frac{3}{8}$	11	$3\frac{3}{8}$	11	$2\frac{5}{8}$	$3\frac{5}{8}$	14
9	22	20	21	18	8	$4\frac{3}{8}$	10	$3\frac{5}{8}$	9	$2\frac{3}{8}$	$3\frac{3}{8}$	16
10	20	18	21	17	7	$4\frac{3}{8}$	9	$3\frac{3}{8}$	9	$2\frac{3}{8}$	$3\frac{2}{3}$	23
11	16	14	23	16	7	$4\frac{3}{8}$	8	4	10	$2\frac{3}{8}$	$4\frac{3}{8}$	21
12	16	11	23	14	6	7	8	4	10	$2\frac{1}{4}$	$5\frac{3}{8}$	16
13	14	10	21	12	$5\frac{3}{8}$	8	7	4	9	$2\frac{1}{3}$	$6\frac{5}{8}$	12
14	13	10	18	12	$5\frac{5}{8}$	7	$6\frac{5}{8}$	$4\frac{5}{8}$	14	$2\frac{1}{4}$	6	10
15	12	12	16	12	5	6	$5\frac{3}{8}$	$4\frac{1}{2}$	16	$2\frac{2}{3}$	6	10
16	10	14	12	12	5	6	5	$4\frac{3}{8}$	14	$2\frac{3}{8}$	$6\frac{3}{8}$	9
17	8	12	10	12	5	$5\frac{3}{8}$	4	4	12	$2\frac{5}{8}$	7	8
18	7	10	8	12	5	$5\frac{3}{8}$	4	$3\frac{5}{8}$	11	$2\frac{3}{8}$	7	7
19	7	9	8	12	5	5	$3\frac{5}{8}$	$3\frac{3}{8}$	10	$2\frac{3}{8}$	$6\frac{5}{8}$	$6\frac{5}{8}$
20	6	8	7	12	$5\frac{5}{8}$	$4\frac{5}{8}$	$3\frac{3}{8}$	4	9	$2\frac{5}{8}$	$6\frac{5}{8}$	$6\frac{5}{8}$
21	7	10	7	17	6	5	$3\frac{5}{8}$	$4\frac{3}{8}$	8	$2\frac{3}{8}$	$6\frac{3}{8}$	6
22	11	11	7	18	8	9	$3\frac{3}{8}$	$4\frac{3}{8}$	7	3	$6\frac{3}{8}$	$5\frac{3}{8}$
23	14	10	9	15	10	7	$3\frac{3}{8}$	4	6	4	$5\frac{3}{8}$	$5\frac{3}{8}$
24	12	9	12	12	9	$6\frac{5}{8}$	$3\frac{5}{8}$	4	$5\frac{5}{8}$	$4\frac{5}{8}$	$5\frac{5}{8}$	$5\frac{5}{8}$
25	10	8	11	10	8	12	3	$3\frac{5}{8}$	5	$4\frac{5}{8}$	5	5
26	9	7	10	9	7	13	3	4	$4\frac{5}{8}$	$5\frac{5}{8}$	$4\frac{3}{8}$	$4\frac{3}{8}$
27	9	7	10	8	$6\frac{3}{8}$	10	$2\frac{3}{4}$	5	4	6	$4\frac{3}{8}$	$4\frac{3}{8}$
28	8	8	11	8	6	9	$2\frac{5}{8}$	10	$3\frac{3}{4}$	$6\frac{5}{8}$	–	$4\frac{3}{8}$
29	7	–	11	8	6	8	$2\frac{3}{8}$	9	$3\frac{3}{4}$	$6\frac{3}{8}$	–	5
30	7	–	10	9	6	7	$2\frac{3}{8}$	8	$3\frac{5}{8}$	6	–	5
31	6	–	9	–	6	–	$2\frac{5}{8}$	9	–	$5\frac{5}{8}$	–	5

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

A

MEMOIR

ON

MOSASAURUS

AND THE

THREE ALLIED NEW GENERA,

HOLCODUS, CONOSAURUS, AND AMPHOROSTEUS.

BY ROBERT W. GIBBES, M. D.

CORRESPONDENT OF THE ACADEMY OF NATURAL SCIENCES, PHILADELPHIA, OF THE BOSTON SOCIETY OF NATURAL HISTORY, ETC.

[Read before the American Association for the Advancement of Science, August, 1849.]

[RECEIVED, NOVEMBER 15, 1849.]

COMMISSION

TO WHICH THIS MEMOIR HAS BEEN REFERRED.

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CAMBRIDGE:
METCALF AND COMPANY,
PRINTERS TO THE UNIVERSITY.

MEMOIR

ON

MOSASAURUS

AND

THREE ALLIED NEW GENERA.

THE great fossil of Maestricht has been a subject of much interest as well as difference of opinion among naturalists; but, after long discussion, the researches of the younger Camper determined its saurian character, and it was by Cuvier referred to a distinct genus, called by Conybeare MOSASAURUS: *The Saurian of the Meuse.* Since its discovery, occasional announcements have appeared of other remains having been found in various localities, chiefly in the United States; — in fact, with the exception of two vertebræ reported by Dr. Mantell as found near Lewes,* and of portions of a large jaw from the Norfolk Chalk,† they are entirely confined to our country.

The first notice of such relics in our palæontology is by Dr. Samuel L. Mitchell,‡ who mentions, as found in the Cretaceous strata of Monmouth, New Jersey, and has figured, "a tooth and part of the jaw of a lizard monster or saurian animal, resembling the famous reptile of Maestricht."

In the fourth volume of the Journal of the Academy of Natural Sciences, Dr. Harlan described a tooth as resembling, "in every respect," those of the "Maestricht Monitor." This was found in the Marl of New Jersey, near Woodbury.

Dr. J. E. Dekay read before the Lyceum of Natural History of New York, in 1830, an account of the remains "of Extinct Reptiles of the Genera *Mosasaurus* and *Geosaurus* found in the Secondary of New Jersey." § He described the tooth alluded to by Mitchell, and referred it unequivocally to *Mosasaurus.*|| He also reported the fact of the existence, in the New Jersey Marl, of the subgenus *Geosaurus*, Cuv., from a specimen in the cabinet of the Lyceum, and called it *Geosaurus Mitchelli.*

* Geology of Southeast of England.

† Wonders of Geology.

‡ Observations on the Geology of North America.

§ Annals of the Lyceum, Vol. III.

|| *Mosasaurus Dekayi*, Bronn, Lethæa Geogn., 1837.

Dr. S. G. Morton, in his Synopsis of Organic Remains, mentioned "teeth and vertebræ found in Monmouth, Burlington, and Gloucester counties, in New Jersey, and at St. George's, in Delaware"; and in the Proceedings of the Academy of Natural Sciences, in November, 1844, described some specimens from New Jersey, and, finding some differences between them and the *Mosasaurus* of Maestricht, proposed provisionally for the former the name of *M. occidentalis.*

The next notice of Mosasaurus is the very full and valuable paper of Goldfuss, published in 1844, "On the Formation of the Cranium of Mosasaurus, with a Description of a New Species," which he calls *M. Maximiliani.**

Among the donations to the Academy of Natural Sciences of Philadelphia in September, 1848, was a portion of a jaw of Mosasaurus, with two nearly perfect teeth, from Freehold, New Jersey; and since this paper was read, another large fragment has been also presented from a neighbouring locality.

I have had in my cabinet for several years vertebræ from Alabama answering precisely to the description and figures of those of Mosasaurus, and agreeing, except in size, with the vertebræ from New Jersey in the museum of the Academy. I have always considered them as belonging to a small species of Mosasaurus. Lately, I received from Alabama a portion of a tooth, which must have belonged to a small species.

I have large vertebræ from the Eocene marl of Mr. J. A. Ramsays, Ashley River, near Charleston, which resembled those figured and described by Faujas St. Fond.†

In the American Journal of Science, ‡ Mr. F. S. Holmes mentions vertebræ from the marl of Ashley River which are similar. During the last year Chancellor Dargan, of Darlington, South Carolina, was kind enough to send me some fragments of bones, chiefly *cetacean*, found in the Pliocene marl of his neighbourhood, among which I found a portion of a lower jaw of Mosasaurus, with the alveolar part of a tooth.

I am indebted to Dr. Willkings, of Wilmington, North Carolina, for a vertebra, identical with those from New Jersey and Ashley River, found in the Eocene of his locality. These references comprise our present knowledge of Mosasaurus.

In the Maestricht individual (which has been called *Mosasaurus Camperi* and *M. Hoffmanni*, but is usually designated by the latter name), the teeth are described as solid and having no true roots, but supported on expanded conical bases anchylosed to the summit of the alveolar ridge of the jaws. These arise from the ossification of the pulpy matter which had secreted the teeth, and are united with and form part of the maxillary bone, the secondary teeth being formed in the substance of this body or ossified pulp. A shallow socket is left where the tooth and its supporting base are shed. They are still further attached to the jaw by the ossification of the capsule that furnished the enamel.§

"The form of the teeth is likewise different from that hitherto observed in any

* Nov. Act. Acad., Vol XIII. "Der Schädelbau des Mosasaurus," etc.

† Hist. Nat. de la Montagne de St. Pierre, Tab. VIII. et IX.

‡ Vol. VII., 1848.

§ Cuvier and Owen.

existing saurian; they are pyramidal, with the outer side nearly plane, or slightly convex, and separated by two sharp ridges from the remaining surface of the tooth, which forms a half-cone (Pl. I. Fig. 1); the transverse section of the tooth near its attachment to the osseous base presenting the contour given at Pl. I. Fig 1. All the teeth are slightly recurved, and their peripheral surface is smooth. They are implanted upon the intermaxillary, maxillary, and premandibular bones. A series of similarly shaped but much smaller teeth are placed upon the pterygoid bones." *

The successional tooth pierced through the osseous body which supported the primary tooth, and this became detached, together with its base, by a kind of necrosis, and fell off, like the horns of a deer.

There are fourteen teeth on each side of the lower jaw in the specimen in the Paris Museum. In the upper jaw there are eleven teeth, but the intermaxillary bone is wanting, on which Cuvier was induced to believe there may have been three. On each pterygoid bone there seem to have been eight teeth. A cast of the Maestricht Mosasaurus may be seen in the Cabinet of the American Philosophical Society.

The vertebræ of this saurian have the form of those of the living Crocodiles, Monitors, and Iguanas, namely, they are concave anteriorly and convex posteriorly: the anterior vertebræ have these characters more strongly marked.

Of the vertebræ there are five sorts, based on the number of apophyses. The first have an upper spinous apophysis, long and compressed; a lower, terminated by a concavity; four articular, the hinder ones shorter and facing outwards, and two transverse apophyses, bulky and short; these are the last vertebræ of the neck, and the first of the back: their body is longer than broad, and broader than high; the faces are of a transverse oval form. Others are without the lower apophysis, but in other respects resemble the preceding. Some follow which have articular apophyses; these are the last dorsal, the lumbar, and the first caudal: their peculiar place is recognized by their transverse apophyses, which are elongated and flattened more and more; the articular faces of their body are nearly triangular in the first caudal. Those which follow have, besides their upper spinous and the two transverse apophyses, two little facets at their lower face to support the chevron-formed bone; the articular faces of their body are pentagonal. Then come others, differing from these in having no transverse apophyses; they form a large portion of the tail, and the faces of their body are ellipses, at first transverse, and then more and more compressed at the sides; the chevron-bone is anchylosed, and forms a body with them, which is a peculiarity. The vertebræ of the tail have no apophyses: in proportion as they approach the end of the tail the bodies are shortened, and almost from its commencement they have less length than breadth or height: the length of the last is one half its height.

Next to the *Mosasaurus Hoffmanni*, the specimen described by Goldfuss is most interesting, as the head is nearly perfect. These remains were found in the Cretaceous formation near the Big Bend in the Upper Missouri, by Major O'Fallon,

* Owen, Odontography.

and were by him presented to Prince Maximilian of Wied, who was at that time on a tour through the United States. They were carried to Europe, and placed in the Museum of Bonn.

The rock in which they were found was so hard, that the most valuable parts of the skeleton were separated with difficulty; but nearly the whole head was procured, and many vertebræ, fragments of ribs, and other bones. Excellent figures are given of the head, jaws, and teeth. A figure of a tooth is given in Pl. I. Fig. 7.

In studying the characters of the prominent bones, Goldfuss came to the conclusion that it is a different species from *Mosasaurus Hoffmanni*, and named it *M. Maximiliani*, in honor of the prince.

The state of the teeth and bones indicates that it had attained its adult growth, although it is only one half the estimated length of the former species. In the upper maxillæ of both there are eleven teeth, but in the lower jaw of the former there are fourteen, while in the latter there are only eleven; in the former the lower jaw is curved, while in the latter it is straight; and in the curve there are eight teeth, while in the corresponding portion of the latter only ten are present.

He describes the teeth of *M. Hoffmanni* as having oblong roots, rounded and touching each other, and as being inserted in a groove in the jaw to two thirds its depth; and the crowns as pyramidal, a little compressed, curved slightly backward, divided by ridges into an anterior and posterior surface having five and seven narrow pyramidal planes on them. Pl. I. Fig. 1.

It will be observed that this description differs somewhat from Cuvier's and Owen's account of the teeth, in the divisional ridges, which the sections show, and in the presence of the longitudinal narrow planes. The divisional ridges in the secondary teeth are on the anterior and posterior surfaces, and not on the lateral. This is plainly seen in the young teeth in the New Jersey specimen, (Pl. I. Fig. 2,) and does not constitute a distinction, as Professor Owen supposed when he founded a new genus Leiodon on this character. Mr. Charlesworth described the same fossil as a *Mosasaurus*, and called it *M. stenodon.** Although the longitudinal planes on the teeth are not mentioned by Cuvier, they may be seen in Faujas St. Fond's plate.

There were eighty-seven vertebræ of *M. Maximiliani* found lying in their proper apposition, measuring thirteen and a half feet long, resembling those of *M. Hoffmanni*, having one surface for the rib attachment, and becoming triangular by degrees; with eleven which are plane. The ribs are perfectly round, as if turned in a lathe, and are identical with those of *M. Hoffmanni.*

Of the small vertebræ from the Cretaceous of Alabama, figured of the natural size, Pl. I. Fig. 3, three were originally found anchylosed, though broken before I received the portion figured. They are identical in all their characters with those of Maestricht, except that they are only of about one fourth the size. I have another of similar size from another locality, and have seen several in the possession of others.

* The Geological Journal, No. I.

The tooth figured in Pl. I. Fig. 4 has the Mosasaurus form, as described by Owen and figured by Faujas St. Fond, and was received from an unknown locality in Alabama. It is solid, and shows the lamellar arrangement very distinctly. A similar tooth from Georgia is figured in Pl. I. Fig. 5.

Their size, taken in connection with the existence of vertebræ which have all the characters of maturity, and evidently belonged to a small individual, disposes me to consider them as characterizing another species, which may be called *Mosasaurus minor.*

The vertebra from Wilmington, North Carolina, (Pl. I. Fig. 6,) appears identical with those found in New Jersey, now in the Academy of Natural Sciences. This seems the most common species, as I have seen similar vertebræ in the cabinets of Professor Agassiz and of Dr. J. C. Warren, from New Jersey; and I have fragments of others from Alabama.

My friend, Dr. S. G. Morton, placed in my hands two teeth of Mosasaurus from the Cretaceous deposits of the banks of the Chattahoochie, Georgia, discovered by J. Hamilton Couper, Esq., which differ from all the described species in their greater compression posteriorly, and in the sharpness and extent of the cutting edges, with a curve backwards giving them the form, on a lateral view, of the teeth of *Megalosaurus.* (Pl. II. Figs. 4, 5.) In honor of the discoverer, a gentleman who has made many valuable contributions to the science of our country, I propose to name this species *Mosasaurus Couperi.*

The portion of a lower maxilla sent me by Chancellor Dargan is interesting from its geological position. It is reported as found with cetacean remains among the shells of the Pliocene. In Darlington, as the beds of Pliocene rest upon the Cretaceous, it is most probable it was derived from the latter formation. Its appearance and the mineralization of its structure render it probable that it came originally from the Cretaceous. I have, from the same Pliocene beds, teeth of *Crocodilus clavirostris*, Morton, (of which Professor Agassiz proposes to form a new genus SPHENOSAURUS,) which in New Jersey is found in the Cretaceous.

The specimens found in Europe are all from the Cretaceous, as well as those from Missouri, Alabama, and New Jersey, while the vertebra from Wilmington was found in the Eocene, as well as those from the marl of Ashley River, South Carolina. From the latter locality I have many vertebræ of *Basilosaurus;* ribs and vertebræ of *Manatus;* a tooth of *Equus* resembling *E. plicidens*, Owen; teeth of *Crocodilus macrorhynchus*, Harlan; and of *Conosaurus*, about to be described.

The fragment of the jaw of Mosasaurus above mentioned is seven inches in length, and constituted a portion of the anterior part of the lower maxilla of the right side. The figures Pl. II. Figs. 1, 2, 3, represent it of the natural size. At the lower outer edge are two large foramina, as in *M. Hoffmanni* and in *M. Maximiliani.* Examined on the inner aspect, (Pl. II. Fig. 3,) we find it is only the portion external to the groove or alveoli for the insertion of the bony roots of the teeth. The base of a tooth, with the pulp cavity, is present, surrounded by enamel, invested by its osseous oblong support, obliquely inserted; and the alveolar surface of attachment of three others is distinctly marked. Here is also seen, on

the osseous support of the tooth, the cavity in which was contained the successional or secondary tooth.* From the size of the tooth and estimated thickness of the maxilla, it must have characterized one of the largest species. The breadth of the bone, from the base of the root to the outer surface, is an inch and a quarter, the inner portion being estimated at the same, and the thickness of the tooth being about an inch and an eighth; where the tooth is present, the jaw is nearly three and a half inches through. The great obliquity in the insertion of the teeth distinguishes it from other species, and the base of the crown of the tooth (Fig. 1) is more circular. As I consider it differing from other American and European species, I propose to call it *Mosasaurus Caroliniensis.*

Since this paper was prepared, Professor Agassiz has kindly allowed me the privilege of examining a portion of a jaw of a specimen from New Jersey, which is figured of the natural size, in Pl. I. Fig. 2. It contains portions of two teeth, with two of the successional teeth making their appearance above the alveolar surface. The former as well as the latter are compressed laterally, a section of the base of the crown being elliptical, not angular as in *M. Couperi.*

The secondary teeth are much more compressed laterally, and the cutting edges are minutely but regularly serrated, which, therefore, is a character of young teeth. The investigations of Professor Agassiz induce him to consider all the specimens from New Jersey as belonging to the same species, including that described by Dr. Dekay, and named by Bronn *Mosasaurus Dekayi*, and which Dr. Morton had provisionally called *M. occidentalis.*

Of this species the specimen in the Academy of Natural Sciences, Philadelphia, from Burlington, New Jersey, is a fine one, containing two nearly perfect teeth.

According to our present knowledge of the genus Mosasaurus, we have in the United States five species: —

MOSASAURUS, *Conyb.*

Mosasaurus Dekayi, *Bronn, Lethæa Geogn.*, II. p. 760. *Dekay in Ann. Lyc. Nat. Hist. New York*, III. p. 135. (1830.)

Mosasaurus Maximiliani, *Goldfuss in Act. Nov. Acad. Leop.-Cæsar. Nat. Curios.*, XIII. (1844.)

Mosasaurus minor, *Gibbes*: vide supra.

Mosasaurus Couperi, *Gibbes*: vide supra.

Mosasaurus Caroliniensis, *Gibbes*: vide supra.

* Figure 3 has been inverted by the draughtsman.

MOSASAUROID GENERA.

HOLCODUS, *Nov. Gen.*

Among my specimens I have a tooth from Alabama given me by Mr. Joseph Jones, of Columbia, South Carolina, and from the latter State another, differing from any which have been described. They are solid, and resemble in their pyramidal form those of *Mosasaurus Hoffmani*, but are compressed antero-posteriorly, the dividing ridges making the anterior and posterior surfaces equal, and they are both convex. They are also acutely pointed. In Mosasaurus the outer surface is a plane, or nearly so, and both have longitudinal narrow planes near the base. In the position of the cutting edges they resemble Geosaurus as described by Professor Owen, but the distinction of this genus, besides the position of the ridges and greater breadth, consists in the edges being serrated. In Professor Agassiz's specimen of *Mosasaurus* the edges are equally serrated, settling the point that serratures are characters of young teeth of *Mosasaurus*. Soemmering conjectured that *Geosaurus* was the young of *Mosasaurus*. This is only the case with what was considered an American species of *Geosaurus* by Dr. Dekay.* The genus *Geosaurus* belongs to formations of an older date than the Cretaceous.

In the teeth under notice, on the outer half, are many planes almost grooves, and also on the inner face, which is peculiarly striated towards the base. It is evidently nearly allied to *Mosasaurus*, and I consider it as forming one of the Mosasauroid family.

As the striated character is a structural distinction, the name of Holcodus † is given to the genus, and that of *acutidens* to the species.

On a recent visit to Professor S. S. Haldeman, of Pennsylvania, I found in his cabinet a well-marked specimen of this new genus from the Cretaceous of New Jersey, which he has kindly allowed me to figure, Pl. III. Fig. 13. The specimen from the Cretaceous of Alabama is represented in Pl. III. Figs. 6, 7, 8, and 9. The other, from the Eocene of Orangeburg, South Carolina, was only a fragment, and has not been drawn.

CONOSAURUS, *Nov. Gen.*

I am indebted to Captain A. H. Bowman, of the United States Topographical Engineers, for several teeth of an acrodont saurian found in the Eocene of Ashley River, South Carolina. At first view I supposed them to be pterygoid teeth of *Mosasaurus*, but they are without divisional ridges or cutting edges, and the section is circular and not elliptical. They are conical, solid, sharp-pointed, slightly

* Annals of the Lyceum of Natural History, New York, Vol. III.

† From ὁλκός, striatus.

curved backward, fluted near the base on the inner face with smooth and fine enamel, and have an expanded osseous support resembling that of *Mosasaurus*. Several are figured in Pl. III. Figs. 1, 2, 3, 4, 5. I propose for this genus the designation of CONOSAURUS,* and for the species the name of the discoverer, a gentleman diligently engaged in developing the palæontology of South Carolina, — *Conosaurus Bowmani*.

In the London Geological Journal, (No. I.,) Mr. Toulmin Smith has figured teeth very similar to these from the Chalk of Lewes. He says, — "The teeth are conical and much curved, perfectly smooth, uncompressed, and with no trenchant edge. They are attached to conical and prominent osseous bases, which are shed with the teeth, leaving very deep circular alveolar cavities, but no trace of a tooth rising from below to replace the one which has fallen out."

AMPHOROSTEUS, *Nov. Gen.*

Professor R. T. Brumby, of the South Carolina College, lately submitted to me two large vertebræ of a Mosasauroid animal, from the Cretaceous deposits of Alabama. They exceed in size any of those figured or described by Faujas, in the Natural History of St. Peter's Mountain.

The size of one (Pl. III. Fig. 11) is, —

Length,	$4\frac{1}{4}$ inches.
Breadth at the middle of the centrum,	$4\frac{1}{2}$ "
Vertical thickness,	$2\frac{1}{4}$ "
Longitudinal diameter of post. articular face,	$5\frac{1}{4}$ "
Short diameter,	$3\frac{1}{4}$ "

It is much compressed, (Fig. 12,) and the ellipse of the convex surface (Fig. 10) is much longer than in *Mosasaurus*; the centrum is more flattened, and the surface of attachment of the lateral apophyses is much thinner (Fig. 12); the concave articular face is much deeper, and the convexity of the opposite end greater, than in any of the vertebræ of *Mosasaurus* which I have examined, and it projects more over the body. Below the edge of the convex articulating face is a contraction, almost amounting to a groove, which is not present in the vertebræ of *Mosasaurus*. The other specimen is represented by Figs. 14, 15, 16, of Pl. III. It seems, therefore, probable that these vertebræ belonged to a huge animal of the Mosasauroid group.

In the measurement of the vertebræ of *Mosasaurus Hoffmani*, no one is represented as larger than two inches in length, and two and a half inches across the articular face. This is about the size of the vertebræ from New Jersey, and of those from Ashley River, South Carolina.

For this remarkable saurian the generic name of AMPHOROSTEUS † is appro-

* From κῶνος, conus.

† From the resemblance of the vertebræ, in outline, to an ancient ἀμφόρα.

priated, and the species is dedicated to Professor Brumby, — *Amphorosteus Brumbyi.*

It may not be out of place to mention, in this connection, that I have in my cabinet, from the Eocene of South Carolina, teeth of *Crocodilus macrorhynchus*, Harlan, and of two nondescript saurians; also from the Pliocene of Darlington, South Carolina, (lying on the Cretaceous,) teeth of *Crocodilus clavirostris*, Morton, and from the Pliocene of Edisto, South Carolina, a new species of *Crocodilus*. I have also vertebræ of true crocodilians from Illinois, Alabama, and South Carolina, which will be made the subject of a future communication.

Columbia, South Carolina, *August*, 1849.

REFERENCE TO THE PLATES.

Plate I.

The figures are all of the natural size.

Fig. 1. *Mosasaurus Hoffmani.*
Figs. 2, 6. *Mosasaurus Dekayi*, Bronn.
Figs. 3, 4, 5. *Mosasaurus minor*, Gibbes.
Fig. 7. *Mosasaurus Maximiliani*, Goldfuss.

Plate II.

The figures are all of the natural size.

Fig. 1. Upper surface of a fragment of the jaw of *Mos. Caroliniensis.*
Fig. 2. External lateral view of the same.
Fig. 3. Inner view of the same, inverted.
Figs. 4, 5. *Mosasaurus Couperi*, Gibbes.

Plate III.

Figures of the natural size.

Figs. 1, 2, 3, 4, 5. *Conosaurus Bowmani*, Gibbes.
Figs. 6, 7, 8, 9, 13. *Holcodus acutidens*, Gibbes; — striated and smooth surfaces.

Figures one fourth of the natural size.

Figs. 10, 14. Convex articular surface of vertebræ of *Amphorosteus.*
Figs. 11, 15. Abdominal surface of vertebræ of the same.
Figs. 12, 16. Lateral views of the same.

NOTE.

Since the preceding paper was placed in the hands of the commission, I find in the February number for 1850 of the Quarterly Journal of the Geological Society of London some interesting notes of Prof. Owen "*On remains of Fossil Reptiles discovered by Prof. H. D. Rogers in Greensand formations of New Jersey.*" He mentions the loss of a paper which he had read before the Geological Society giving a more particular account of these fossils, but gives the general results of his investigations.

The examination of Prof. Rogers's specimens of vertebræ led Prof. Owen to notice a division of those which were Crocodilian into two series, based upon a character of the *hypapophysis*. In the one it is single, and in the other cleft. Other characters induce him to consider the vertebræ in question as belonging to the "oldest of the modern Crocodilian family."

For that distinguished by the single hypapophysis, he proposes the specific name of *C. basitruncatus;* while for the cleft apophysis he adopts that of *C. basifissus*. These vertebræ are identical with several in the cabinet of the Academy of Natural Sciences of Philadelphia, which have been described by Prof. Agassiz in the proceedings of the Academy of National Sciences, on which he founds two new genera, *Sphenosaurus* and *Bottosaurus*. Of Mosasauroid vertebræ, Prof. Owen describes and figures some of the same type as those of *Mosasaurus*, but "longer and more slender"—thinks they may belong to *Leiodon*, but in the absence of confirmatory evidence prefers to refer them to a new genus, "*Macrosaurus*." The figures resemble precisely the vertebræ of those of a fine specimen discovered by Prof. Tuomey in Alabama, now in the care of Prof. Agassiz for description. As the maxillary bones and teeth are in good preservation, we may anticipate much valuable addition to our stock of knowledge of this family of Saurians.

Prof. Owen also gives figures of other vertebræ characterized by the large size, and especially the great antero-posterior extent of the hypapophysis, and the concavity of the articulating faces resembling those of the *Teleosauroids*. These he considers as constituting a new genus, which he calls *Hyposaurus*, and dedicates it to our eminent Geologist, Prof. H. D. Rogers.

I had hopes, before the addition of this note, to have had the opportunity of examining the collection of Prof. Rogers, but the box containing the specimens was accidentally mislaid, and has not yet reached me.

Nov. 1, 1850.

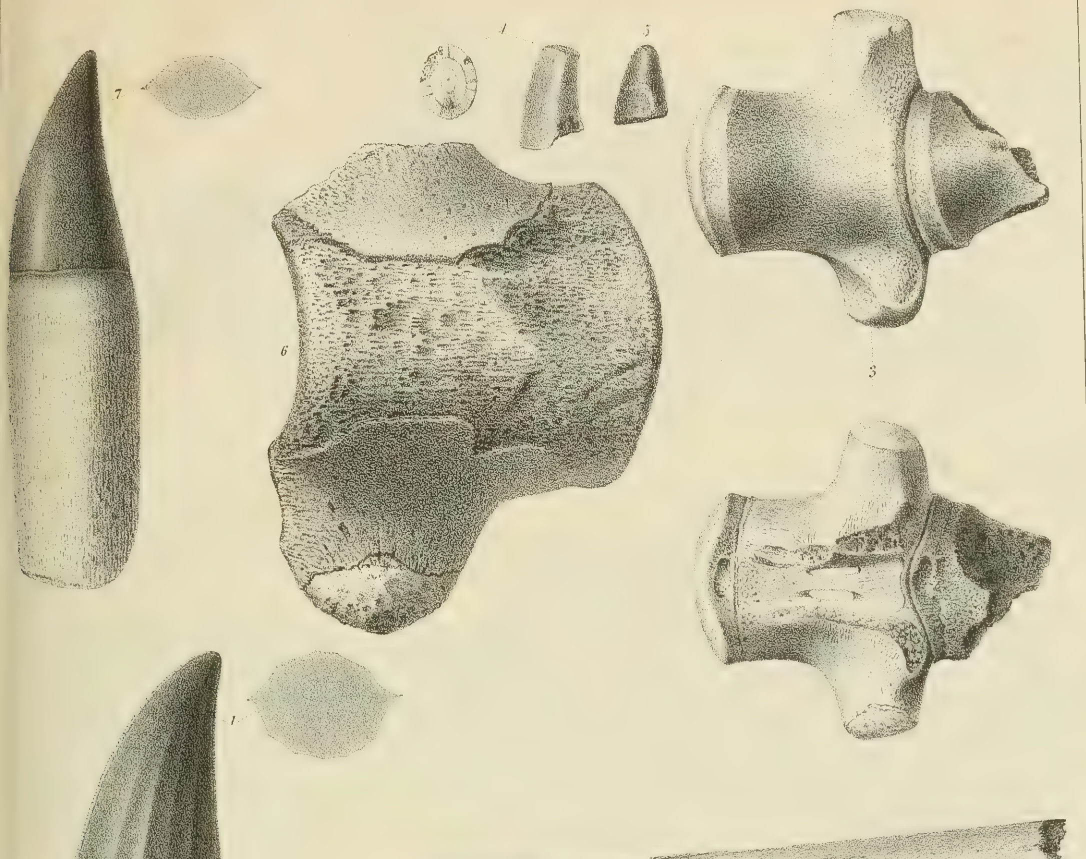
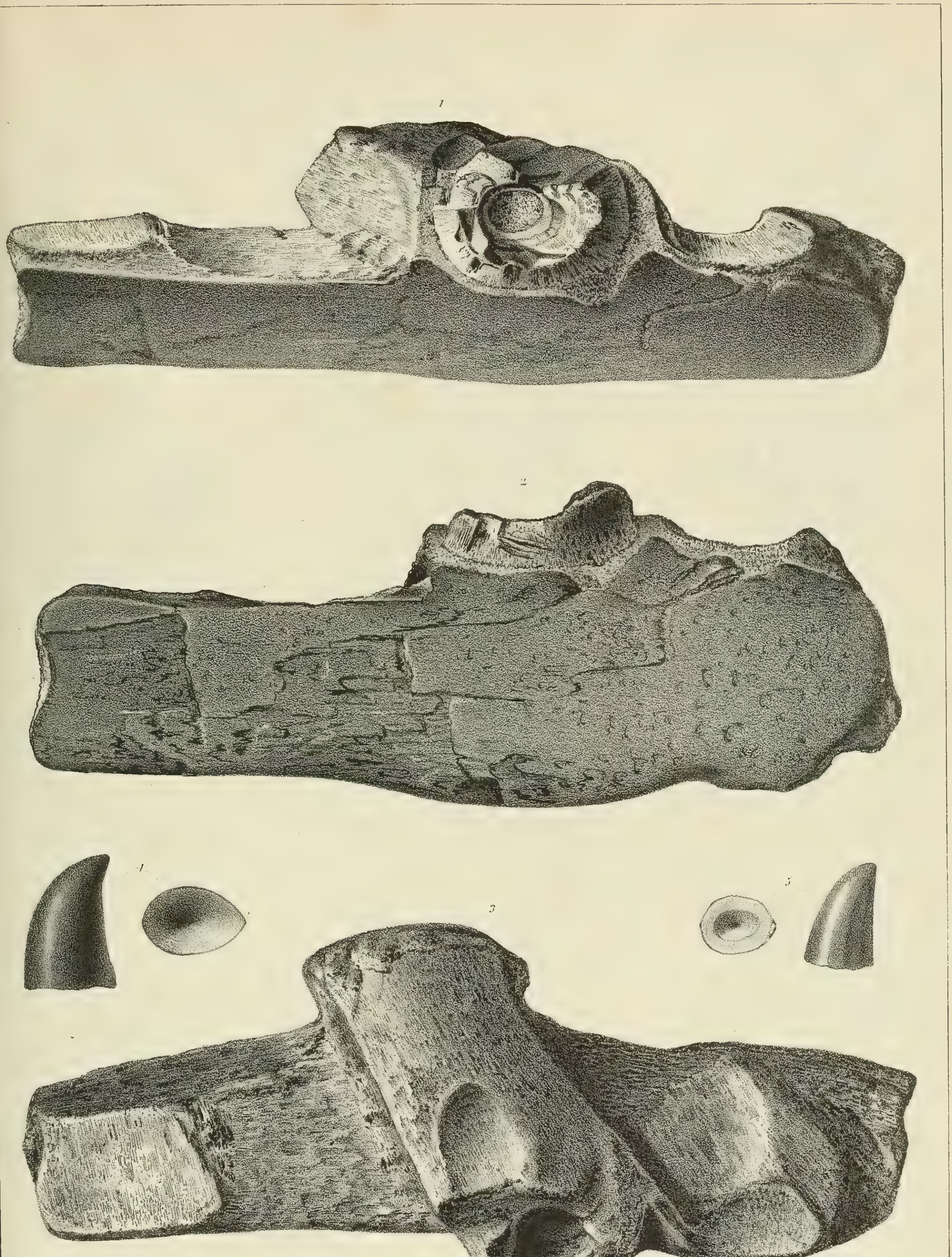
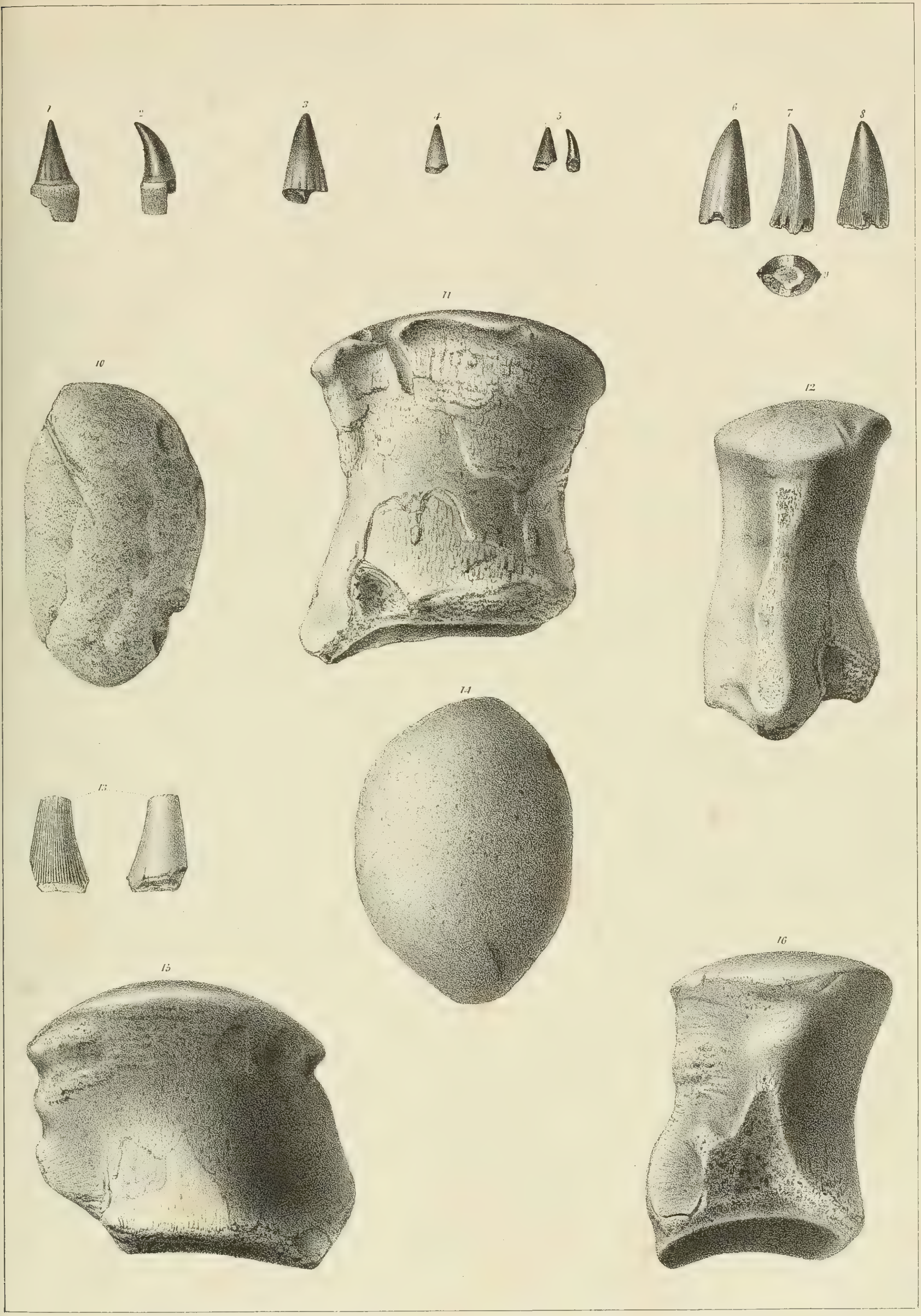


Fig. 1 Mosasaurus Hoffmani.
Figs. 2. 6. „ . Dekayi. Bronn.
Figs. 3. 4. 5. „ Minor. Gibbes.
Fig. 7 „ Maximiliani. Goldfuss.

T. Sinclairs lith. 101 Chesnut St. Phil.



Figs. 1. 2. 3. Mosasaurus Caroliniensis. Gibbes.
Figs. 4. 5. „ Couperi. Gibbes.



Figs. 1 to 5. Conosaurus Bowmani. Gibbes
Figs. 6. 7. 8. 13. Holcodus acutidens. Gibbes
Figs. 10 to 16. Amphorosteus Brumbyi. Gibbes.

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

THE

CLASSIFICATION OF INSECTS

FROM

EMBRYOLOGICAL DATA.

By Prof. LOUIS AGASSIZ.

[Presented to the American Association for the Advancement of Science, at Cambridge, August, 1849.]

[Received, March 6, 1850.]

VOL. II. ART. 6.

COMMISSION

TO WHICH THIS MEMOIR HAS BEEN REFERRED.

PROF. C. D. MEIGS.

THADDEUS W. HARRIS, M. D.

JOSEPH HENRY, *Secretary.*

CAMBRIDGE:
METCALF AND COMPANY,
PRINTERS TO THE UNIVERSITY.

THE

CLASSIFICATION OF INSECTS

FROM

EMBRYOLOGICAL DATA.

I. General Considerations.

The various classifications of Insects which have been proposed by zoölogists rest either on considerations derived from their external characters and form, and in part from their internal structure, or on the various modes of their development from the egg. The earliest writers on classification availed themselves principally of the number and structure of their wings, to divide the numberless insects into several general divisions, and such an arrangement, as finally adopted by Linnæus, has prevailed to a great extent, sometimes modified by the introduction of some smaller groups, which have been more generally admitted by English writers than by those of the Continent of Europe.

Fabricius introduced an entirely new view of the subject, dividing the insects according to the structure of the organs by which they take their food, and the various structures and degrees of complication of the jaws became the foundation of his system, which he not only applied in a general manner, but worked out in all its details, assigning even to the smaller divisions characters derived chiefly from the peculiar form of those parts.

More recently the metamorphosis of insects has been made the foundation of their classification, and they have been grouped according to the extent of the changes they undergo from the egg, and according to the condition in which the young animal remains for a time before it has arrived at its complete perfect growth.

According to these views, those insects that are hatched from the egg with a form very similar to the full-grown perfect animal, and which undergo slight or only partial changes during their growth, such as the additional development of wings, or which remain active throughout their metamorphosis, have generally been considered as belonging to one and the same great division, and have been brought together as insects without metamorphosis, or with imperfect metamorphosis. On the other hand, such insects as are hatched from the egg in the form of a maggot,

grub, or caterpillar, resembling worms in their earlier period of life more than they resemble the perfect insects which are to grow out of them, and from that condition passing into the state of immovable, mummy-like pupæ, or chrysalids, and during this period taking no food, but afterwards giving rise to a winged, perfect fly, beetle, or butterfly, have been considered as insects with perfect metamorphoses, and on that account have been brought together in one great division.

A glance at the classifications resting upon such considerations will show, that each of these fundamental divisions contains insects, which, in their perfect condition, chew their food with powerful jaws, and others which are provided with suckers to pump the more liquid nourishment upon which they live. It has long been a question with me, whether the nature of the metamorphoses or the structure of the jaws was to be considered as the prominent character on which to found the primary divisions. It struck me as possible, that a classification, in which the chewing insects should be brought together, and all sucking insects combined in another group, and both then subdivided according to their transformations, might lead to as natural an arrangement as a classification resting in its fundamental divisions upon considerations derived from the metamorphoses alone. In order to satisfy myself upon the importance of these two sets of characters, I have examined the metamorphoses themselves, which various groups of insects undergo, and have been deeply impressed with the fact, that most of those insects which undergo the so-called complete metamorphoses are provided, in their early stages of growth, with a chewing apparatus, which is gradually transformed into the various kinds of suckers with which the perfect insects are provided.

This led me to the question, whether the structure of this peculiar apparatus for chewing food did not indicate, among insects, a condition of existence lower than that of those insects which assume during their metamorphosis another type of jaws in the shape of a sucker. And upon that suggestion I attempted an arrangement of the different orders of insects, which seems to me not only more natural, but to correspond more fully with the lessons of embryology. I propose the following classification: —

I. *Chewing Insects* (Mandibulata).	II. *Sucking Insects* (Haustellata).
NEUROPTERA,	HEMIPTERA,
COLEOPTERA,	DIPTERA,
ORTHOPTERA,	LEPIDOPTERA.
HYMENOPTERA.	

The reason why Coleoptera have been so universally considered as the highest among insects, is plainly shown by the position assigned to Cicindela, which is placed at the head. That group is the most carnivorous of the order. But I do not think it right to assign to the carnivorous insects the highest rank, if there is no other reason to consider them as such than the fact, that among Mammalia the Carnivora rank higher than the herbivorous animals.

Far from inclining to such views, I am prepared to show that the very fact of the complication of their jaws, and the multiplication of their parts, the greater resemblance which those parts have to common legs, the immobility of the prothorax, the hardness of their anterior wings, the frequent deficiency of the lower wings, the similarity in structure between the jaws of the larva and those of the perfect insect, are so many characters which assign to the Coleoptera a lower rank than that of the Lepidoptera.

Indeed, if we institute a comparison between Coleoptera and Lepidoptera, we are struck with the greater resemblance between the former, when perfect, and the caterpillar, than between the beetle and the butterfly. It may be said, that the beetle preserves the characters of the larvæ of other insects, and assumes only wings and more developed legs in addition, without reaching other successive metamorphoses, — those other changes through which the caterpillar passes before it is transformed into the perfect imago.

This being once granted, it must be acknowledged, in general, that chewing insects should rank lower than sucking insects; and we may perhaps find in the complete metamorphoses of the higher Haustellata sufficient data to carry out this view in determining the relative position to be assigned to all the orders of that class.

Among the mandibulate insects, for instance, we have, besides Coleoptera, the Orthoptera, Neuroptera, and Hymenoptera. Now, the Neuroptera, though undergoing metamorphoses as complete, in many respects, as the Coleoptera, have larvæ whose structure seems decidedly lower than that of the Coleoptera, for they are mostly aquatic worms, provided not only with powerful jaws and all the complicated chewing apparatus of mandibulate insects, but also with aquatic respiratory organs, namely, true external gills similar to those of the aquatic worms. And the great and complicated changes which they undergo, both in structure and form, lead to a development which does not rank higher than that observed among Coleoptera. Indeed, the soft wings of Neuroptera indicate, in my opinion, a character of low development; for their peculiar structure resembles more that of the wings of the young butterfly, before passing into the condition of the pupa, than that of the elytra. The wings of Coleoptera, again, resemble more closely the condition of the wings in the pupa of the butterfly, at the period when the outer wing is hardened and soldered to the body, covering the lower wings, which remain soft. I would, therefore, without hesitation, place Neuroptera as the lowest order among Mandibulata.

Next might come the Coleoptera, followed by the Orthoptera ; for Hymenoptera, no doubt, rank highest in this division. To satisfy ourselves that this is the case, we need only consider the structure of their jaws, the upper pair of which alone preserve the character of chewing insects, while the lower are transformed into a kind of proboscis very similar to that of Haustellata. Again, their larvæ rank higher than the larvæ of either Neuroptera or Coleoptera. They are for the most part larvæ with aerial respiratory organs, and, in that respect, rank decidedly above those of Neuroptera, and might be considered as of equal value with those of Coleoptera.

Though the fact, that many Hymenoptera have caterpillar-like larvæ, will at once place them one stage higher, that is, nearer the Haustellata, some facts presently to be mentioned, respecting the changes which caterpillars undergo before they pass into the state of complete pupæ, will establish more fully the value of this argument.

There is, however, one order of chewing insects, the position of which is somewhat embarrassing; I mean the Orthoptera. If the views expressed above are correct, the very fact of their having chewing jaws will place them among the Mandibulata, below the Haustellata. But what is the proper position to assign to them among Mandibulata? They cannot be placed higher than the Hymenoptera, for their jaws are completely masticatory. But their position in relation to Coleoptera and Neuroptera is difficult to determine. They undergo no change after they have been hatched from the egg, except that of assuming wings. They are born from the egg with an aerial respiratory system; indeed, in a condition which is already higher than that of the larvæ of Coleoptera, and decidedly higher than that of the Neuroptera. We should, therefore, look to the changes which these animals undergo within the egg, to determine their true position. But upon this point observations are still wanting. At present I am inclined to place them above Coleoptera, as we generally find that the degree of perfection which the young assumes before it is hatched corresponds, to a remarkable extent, with the perfection of the animal in its general structure. And if it were not for the peculiar structure of the jaws in Hymenoptera, I should not hesitate to place Orthoptera highest among Mandibulata. Again, the perfection of the wings of Hymenoptera leads so decidedly to a parallelism between them and some of the moths, that I cannot help thinking the best arrangement is the one mentioned above; namely, Neuroptera lowest, next Coleoptera, next Orthoptera, and Hymenoptera highest. The peculiar piercers, with which so many Orthoptera are provided to lay their eggs, remind us of similar apparatus in Hymenoptera, which would go to substantiate the position now assigned to these two orders of insects, in close juxtaposition.

Let us now consider the different orders belonging to the division of the Haustellata, which contains only three great groups, the Hemiptera, Diptera, and Lepidoptera. The order in which I have mentioned them above seems to me to be that in which they should naturally be placed, according to their structure and metamorphoses. If we can be guided by the changes which the highest of these animals undergo, it will be perceived that among Lepidoptera we have the true key for their natural arrangement. The larvæ of this last group are hatched in a condition far superior to that of the larvæ of any other insects. Not only are they all provided with aerial respiratory organs, but the different regions of their body are already more fully marked out than in the larvæ of any other insects, by the different structure of their various legs, and by the decided distinction which is introduced between the head and body. Moreover, their skin is variously colored, and provided with a most astonishing diversity of external appendages.

At first, these animals are voracious in their habits. Provided with powerful jaws, they chew large quantities of food, mostly derived from the vegetable kingdom.

But before they undergo their metamorphosis into pupæ, before casting the last skin of the caterpillar, the young Lepidoptera begin to form their wings, which grow out of the second and third ring of the thorax in the shape of short, folded bags, very similar indeed to the first rudiments of wings in Neuroptera. These appendages rapidly enlarge, and when the caterpillar casts its skin, they have already attained a considerable size. But, instead of remaining free, they are soldered to the body of the pupa, the outer wings become hard, and form what have generally been called the wing-covers, resembling then very much the wings of Coleoptera. But the jaws have undergone greater changes. They are now transformed into long appendages, similar to the articulated threads which constitute the sucking apparatus of Hemiptera and some Diptera. The resemblance of the jaws of Lepidoptera at this period to those of Hemiptera is so great, that we may truly say, that the form of this apparatus in the pupa completely exemplifies the permanent structure of the sucking apparatus in Hemiptera; and the hardness of the wing-covers reminds us at the same time of the hardness of the base of the upper wings in the greater part of Hemiptera; so that Hemiptera, in their perfect condition, would correspond to the earliest condition of the pupæ of Lepidoptera. So the higher degree of locomotive power of these parts in Diptera would remind us of the condition of the jaws in the Lepidoptera, at the moment the perfect butterfly leaves its pupa, when the pieces of the mouth move independently of each other, as is the case with the piercers of most Diptera, which remain free, while in Lepidoptera they finally form the articulated proboscis. This type of jaws of the Diptera, intermediate between those of Hemiptera and the perfect Lepidoptera, would therefore assign to them also an intermediate position in the system.

Again, the peculiar development of the wings, the anterior of which become perfect and membranous in Diptera, while the posterior ones remain rudimentary, shows plainly that in the character of their wings, as well as in all other respects, Lepidoptera rank highest among Haustellata, and therefore highest among all insects.

Whatever be now the value of these considerations, it must be obvious to all those familiar with the subject, that such a classification differs radically from the classifications founded upon metamorphosis simply. For here the system is founded, not merely upon the fact of the insects undergoing changes to various extent, but upon the nature of the changes themselves. This is a genetic classification, based upon embryological changes, while the classification of the physico-philosophers rests simply upon the circumstance of the insects undergoing metamorphoses or not, without direct reference to the particular character of the successive changes. They bring together Hemiptera and Orthoptera, because both undergo hardly any changes after they have been hatched from the egg. But here it is shown that the peculiarities which characterize Hemiptera correspond, to a certain degree, to the transformations which Lepidoptera undergo, and that Hemiptera therefore appear, upon embryological data, to belong to the same series, to which we must also refer Diptera and Lepidoptera, but from which Orthoptera are excluded. Again, accord-

ing to the views of the physico-philosophers, the Coleoptera, Neuroptera, Hymenoptera, Diptera, and Lepidoptera belong together, because they undergo extensive changes in their metamorphoses. But I have already shown that, however extensive these metamorphoses may be, they do not rise in any of these orders beyond the development which the Lepidoptera attain in their pupa condition; as in the pupa of Lepidoptera the jaws are already transformed into a sucker-like proboscis, when wings and legs are developed ; while Coleoptera, Orthoptera, and Hymenoptera have arrived at their mature condition before the jaws have reached a higher development of structure than that which is exemplified in the metamorphoses of Lepidoptera before they fully pass into the condition of their pupa. So that, notwithstanding their extensive metamorphoses, the mandibulate insects must be placed altogether below the haustellate, even below the Hemiptera; and thus the classification proposed at the outset seems fully justified by embryological evidence; and, if I am not mistaken, we shall in future consider Mandibulata as forming one great natural division among insects, to be placed below the Haustellata.

This conclusion furnishes another illustration of the fallacy of our reasoning, when we allow ourselves to be guided simply by analogy derived from other classes. If among the higher animals we had not a natural series passing from man, through monkeys, to the carnivorous animals, I doubt very much whether we should ever have been led to consider the muscular power and the strength of the jaws as indicating anywhere a higher degree of organization. But this impression, which is correct among Mammalia, can no longer obtain in other classes. We should, on the contrary, be better advised, by this evidence, and in future derive our views, as far as possible, solely from the classes to which they are to be applied.

The same evidence which shows Lepidoptera to rank highest among Insects, shows also that Insects as a class rank higher than Crustacea. And it will not be out of place to remember here the happy suggestion of Oken, who says, that "Lepidoptera are born as Worms, then pass into the condition of Crustacea, and are finally developed into true Insects, exemplifying the natural order of gradation of the three classes of Articulata."

The detailed history of the metamorphoses of some Lepidoptera will sustain more fully the views introduced in the preceding pages.

II. The Metamorphoses of Eudamus Tityrus.

There is no order in the class of Insects the transformations of which have been more extensively studied than those of Lepidoptera. The knowledge of their earlier condition has been of late so much extended, that entomologists have even derived many important characters for their classification from the investigations of these earlier stages of growth. There are, however, several subjects of importance, in a physiological point of view, to which attention has not been sufficiently directed. Though we know the different forms of the larva, of the pupa, and the perfect insect, and though in most cases Lepidoptera may now be recognized in either of these conditions, the manner in which the changes are brought about has not been sufficiently examined.

Caterpillars as such have been minutely described and figured. The differences they show in form and color, and even in the details of their external appendages, have been noticed in most species. The chrysalis, also, has generally been described and figured, though perhaps not with the same degree of minuteness as the caterpillar, whilst nothing can exceed the minuteness and precision with which naturalists have described and figured the perfect insects. Indeed, the illustrative works we now possess of this class exceed in beauty, perfection of execution, and minuteness of detail and coloring, all the illustrations of a similar kind relating to other classes. But those periods of transition in the life of Lepidoptera, those short intervals during which the caterpillar passes into the state of a pupa, and the pupa, again, into the condition of the perfect winged butterfly, have been more neglected, probably for the very obvious reason, that, during these periods, as is well known, those animals are more delicate, and more apt to die or to be injured if disturbed.

Perceiving, however, the importance of a close investigation of these stages in their metamorphosis, with reference to a full understanding of the process by which a lively, ornamented worm passes into the condition of a mean, enfeebled, mummy-like animal, inclosed in a hard case, deprived of external appendages of any kind, — and then, again, of the process by which this passes into an insect provided with well-articulated legs, a long proboscis, prominent antennæ, and large wings adorned with diversified colors, — I undertook to secure a sufficient number of larvæ of several species of Lepidoptera, to afford me ample opportunities for deliberately investigating them during the period of their transformation. Some of the results of these researches I shall now relate.

In order not to be misunderstood, I would mention that I allude here to the actual transition from one of the temporary stages in the metamorphosis of these insects to another, that is to say, to the passage of the caterpillar to the chrysalis, and that of the chrysalis to the perfect Lepidopter, and not to the different stages under which these insects appear temporarily for a longer or shorter time, and which are already so well known. Nor do I mean to introduce the subject of the changes in the internal structure during those metamorphoses, which have been so ably investigated by Herold. My chief object is to illustrate comparatively the morphology of these different stages in their transitions into each other.

As the most prominent and striking changes occur in the external form, my first object was to investigate the structure of the skin, especially of its inner layers, which seem to be the seat of a peculiar activity in this process of transformation. But I must confess that, up to this day, I have been unable to ascertain how the new skin developes under the old, at each moulting, in any of the insects. I can only suggest that the fact of extensive blood-currents flowing over the lower part of the body, and upwards along the lateral walls of each ring, to meet again the dorsal vessel, is very probably connected with this important function, and increased activity of the skin. But how the new layers are deposited, how the appendages themselves, which are successively modified, or entirely formed anew, are developed, and what is the nature of the function by which they are produced, I am unable to state. The results at which I have arrived do not go beyond an illustration of the

comparative morphology of these parts. But perhaps this beginning will successively lead to a full understanding of the phenomenon; and as these facts were chiefly traced from the larva of Eudamus Tityrus, I shall describe more particularly what I have observed in that species, and occasionally introduce some reference to what I have seen in others.

This butterfly lays its eggs separately, one by one, (Fig. 1, egg of natural size,) upon the leaves of *Robinia viscosa* and *pseudacacia*, to which they are attached by a broad, flattened surface. The walls of this attached surface are smooth, and much thinner than the other part of the circumference of the eggs, which is otherwise almost spherical (Fig. 1, *a*). Its color is grass-green. The upper rounded end shows a small circular depression (Fig. 1, *b*), also thinner than the sides. The sides are adorned by sixteen vertical ribs (Fig. 1, *b* and *a* *), which are denticulated externally, eight of the ribs meeting the upper circular depression, while eight are shorter. Some time before the caterpillar is hatched, it appears like a dark reddish-brown band across the egg, about the middle of its height. At a later period, and not long before it is hatched, the caterpillar may be seen through the shell of the egg moving in jerks within its cavity. Its darker reddish color renders it then very conspicuous. Though I have often tried to secure a sufficient number of these eggs, I have not been able to trace the mode of formation of the larva itself within the egg, and its changes during its ovarian growth. For those eggs which I have had an opportunity of investigating, and one of which is represented in Fig. 1, I am indebted to Dr. T. W. Harris, of Harvard University, whose extensive knowledge and acquaintance with the metamorphoses of insects are too well known in the scientific world to require notice from me. I can only state, that, when hatched, the young caterpillar has the same form that it preserves throughout its growth.

The head is already dark blackish, and shows two small orange spots above the outside of the mandibles. The collar is also darker than the following joints. However, the color of the main body at that period does not contrast so much with that of the head and collar as it does afterwards; the second and third thoracic joints, and the whole series of abdominal joints being then reddish-orange, and assuming only after the first moulting the same greenish-yellow color which it has afterwards, and which is the final color of the animal. This fundamental color, however, is not uniform, as we observe minute blackish spots about the stigmata, and also upon the back, as well as several small greenish-black streaks across each ring. (Figs. 2, 3, 4, 5, 6.) The thoracic legs are reddish, and the prolegs somewhat orange. As in all caterpillars of Lepidoptera, the number of joints of the body is thirteen, the head being considered as one, though, from various indications, we may admit that it consists itself of three soldered segments. The thorax has three joints, provided with three pairs of horny feet, terminating in a claw. There is, however, a marked difference in the caterpillar between these three joints; the first being smaller and shorter than the second, and of a dark reddish-black color, the joint between the head and collar reddish, and the collar itself reddish-

* One of the ribs is still further enlarged in Fig. 1, *c*.

brown, or blackish. Of the following abdominal rings, the first and second, or the fourth and fifth behind the head, are deprived of locomotive appendages, but the third, fourth, fifth, and sixth, or sixth, seventh, eighth, and ninth, are provided each with a pair of ambulatory feet, the extremity of which is surrounded by a crown of minute hooks. The next two joints are deprived of legs, but the last joint is again provided with a pair of prolegs, differing somewhat from the middle ones in being more compressed laterally.

With these characters the caterpillar arrives at its maturity, and when it has done eating, after walking about for some time in search of a convenient place for its transformation into a pupa, fixes itself with some silk threads by the tail, throws a few others across its body, and spins a very thin, transparent, loose cocoon, or rather a kind of incoherent net, between the leaves which it folds around itself, and remains quiet to undergo its first great change, and to pass into the state of chrysalis. (Fig. 7.)

The first marked modification from its former condition consists in a general shortening of the body. (Figs. 8, 9, 10.) The whole larva contracts for about one third of its length, and thus assumes permanently a position which it shows sometimes when at rest. But even after it has thus become quiet, it will, when disturbed, again move about in search of a more protected shelter.

If left undisturbed, the body is seen to swell, especially in its anterior part, which seems to be in a state of chronic inflammation, as it were, having the appearance of an œdematous swelling, distended by a considerable accumulation of lymph.

The thoracic region and the head are at this time the chief seats of the formative process, and of a more active process of nourishment; the other parts seeming rather to wither, the skin to shrivel, and the prolegs to dry up. Indeed, before long, the skin of the larva is sufficiently loose to be separated without much difficulty from the pupa forming underneath; and by watching carefully the moment when the skin splits upon the back in the process of being naturally removed, the whole process may, with some assistance, be accelerated, and the skin turned away before the chrysalis is entirely formed. (Figs. 11, 12, 13.) At this moment the young animal presents characters so different from the perfect pupa, that, unless the whole process has been carefully watched, no one would suppose that the forms it then exhibits are really the next transformation of the larva towards its change into a chrysalis.

Indeed the chrysalis, when perfect (Fig. 7, 7 *a*, 7 *b*), presents a hard case, upon which, with some attention, we may distinguish the outlines of the abdominal joints and the thorax; upon the sides of this, and below it, an outline of the future wings may be recognized, as well as superficial indications of the legs underneath, bent backwards between the wing-covers; there is likewise a tubular flattened case, representing the antennæ; and upon the middle line, a similar one answering to the proboscis. (Fig. 7.) All these parts are soldered together, and upon the skin itself, so closely as to be entirely immovable, and to appear rather as a protecting envelope of the organs, the form of which they foreshadow, than as these

organs themselves. Nevertheless, if we carefully watch the process of the last moulting, or, rather, if we are successful in removing gently the larva-skin before the pupa is hardened, we see that all the above-mentioned organs exist in reality, wholly independent and entirely free from each other, (Figs. 14, 15, 16, 16 *a*, 17, 18, 19, 19 *a*,) though still imperfectly developed, since the legs are mere cylindrical tubes without regular articulations (*a*, *a*); since the antennæ present a similar tubular appearance, somewhat swollen towards the end, but without joints (*b*, *b*); since the maxillæ project as two independent tubes, also very much like another pair of legs (*c*, *c*); and since the wings appear as four distinct, swollen, but somewhat flattened vesicles (*d*, *d*), identical in appearance with the lateral respiratory vesicles of Annellides, sufficiently large, however, to remind us of the wings as they appear when the perfect insect has come out from the chrysalis. We have, therefore, an apparently complete butterfly, somewhat imperfect in its characters, coming out from the larva with all its parts independent, prior to the period when these parts are pressed upon the sides of the animal, and soldered with its walls.

The process by which these parts are pressed flat, and made to adhere to the body, is connected, no doubt, with the act by which the pupa escapes through the narrow slit on the back of the skin of its larva; but when the larva-skin is gently removed, and the pressure prevented, these parts will all remain free, and dry up in an irregular connection, and shrivel in an irregular fusion. Or if, immediately after the removal of the larva-skin, the young animal be placed in water with a few drops of alcohol, the parts will remain expanded, and may afterwards be preserved in that condition in a stronger liquid. So that we may derive imperfect butterflies directly from larvæ, sufficiently similar to the butterfly which escapes from the pupa to be readily recognized, and presenting all the characters of the perfect butterfly, except the imperfect articulations of the legs and antennæ, the unconnected maxillæ, and the vesicular wings.*

The position of these wings is rather symmetrical. They are bent backwards and downwards, the upper surface outside; and this is the case even in those Lepidoptera which, when full grown, fold their wings upwards, with the upper surface turned inwards, and the inner or under surface outwards. This fact is of great importance, as it shows that all the Lepidoptera, which naturally keep their wings bent downwards in the form of a roof, must be considered as lower, in their

* These facts, which I believed to be entirely new to science when I first observed them, have already been noticed to some extent, and are mentioned in the following manner by Burmeister, in his Manual of Entomology, p. 426 of the English translation : —" After the third moulting, when the larva has acquired its full size, the rudiments of the wings begin to form beneath the skin, upon the first and second segments. They at first present themselves as short viscous leaves, the substance of which greatly resembles that of the mucous tunic, and to which many delicate tracheæ pass, which distribute themselves throughout them. These rudiments increase with the growth of the caterpillar, and betray themselves, even externally, by both the segments of the caterpillar, upon which these rudimentary wings are found, appearing swollen and spotted. Their enlargement probably takes place by the assistance of the blood flowing into them. Simultaneously with the perfecting of these rudiments, the intestinal canal increases in compass, and, as a consequence of this increase, there is a greater accumulation of the fatty mass. A

respective families, than those which raise them upwards. We may, therefore, learn from this fact, that the diurnal Lepidoptera rank higher than the crepuscular and nocturnal ones. This hint would, of itself, be an ample reward for the time spent in these investigations, even if we did not further learn from them that there is a strict homology between the wings of butterflies and the respiratory vesicles of Annellides, and that the physico-philosophers (I mean particularly the acute Oken) are fully sustained by material facts when they assert that insect-wings are transformed gills.

When the metamorphosis of the larva is allowed to go on undisturbed, this immature butterfly, with a comparatively long abdomen, still further contracts. The abdomen especially is considerably shortened (Figs. 17, 18, 19, 19 *a*) and thickened, though its joints remain movable. But the head and thorax and all their appendages are soldered together, and form a solid, immovable case; and the connection of the external appendages becomes so intimate, that, instead of appearing like independent parts, they assume rather the appearance of outlines of those organs carved upon a surface, as if they were mere indications of the parts to be developed in these regions (Figs. 20, 21, 22), but seeming to be as yet unformed. Nevertheless, as I have shown above, they were all independent shortly before, and have become gradually more and more united in the perfect pupa.

This transformation is, again, of very great importance with reference to our classification of articulated animals, as it shows that the condition of those Articulata in which head and thorax are united is a lower degree of development than the condition of those in which head and thorax are distinct. We have, indeed, here an additional evidence of the views which I have maintained on another occasion, that the Crustacea — in which the thoracic and cephalic joints are either entirely independent of each other, as in the larvæ of Lepidoptera, or united in one continuous case, the cephalo-thorax — rank below the true Insects, and also that Arachnidæ, the spiders, are inferior to the Insects proper.

The transformation of the pupa into the perfect insect (Fig. 23) takes place in the same manner as the transformation of the larva into a pupa, in consequence of another moulting, during which the surface of the animal undergoes its last changes, and assumes the characteristic peculiarities of the perfect insect. The difference, however, between the perfect Lepidopteron and the pupa is much less than the

transformation is also taking place in the anterior feet of the caterpillar, for the larger legs of the butterfly begin to form. But, as a similar transformation is going on in the oral organs, the caterpillar loses its desire to eat and power of mastication, it ceases to receive food, and prepares itself for its last moulting, namely, for its change into the pupa. It seeks for this purpose an appropriate place, where it can lie, hang, spin, or attach itself, and it accomplishes this, its last business, the same as its earlier ones, with great care and consideration. After its situation and web are prepared, it reposes a few days, then strips off its skin, and now presents itself as a pupa, with the visible limits of a butterfly."

It is surprising that this observation should not have led its able author to trace these facts further, and to recognize their bearing upon the classification of Articulata in general, and that of Insects in particular, as well as upon the appreciation of the relative value of the organs in the various development they present in this type of animals.

difference between the pupa and caterpillar, though the contrary would seem to be the case. However, from what I have said above, it is plain that the Lepidopteron arises from the larva with most of its perfect features, only developed in a less finished manner, while the changes which the animal undergoes during the pupa state only consist, as it were, in the last perfecting of the final development already introduced during the last period of the larval life.

The skin of the pupa, having acquired its complete hardness, the appendages having been soldered together, and now constituting a continuous case, in which skin, legs, wings, antennæ, and jaws are fused together, is gradually separated from another more perfect envelope, which is to be the last covering of the last period of life of the butterfly. All the ornamented appendages of this skin, — its well-articulated legs, its feathery wings, its articulated antennæ, its facetted eyes, its elongated movable maxillæ, — when perfect, remain separate from each other, movable upon each other, and independent in their functions, and do not undergo again a fusion similar to that by which the case of the pupa was formed and thickened. The only connection which grows more intimate in the perfect animal than it was in the pupa is that of the two maxillæ, which henceforth are united along the middle line, and between which a groove is left to form the curved proboscis. Gradually all these parts are loosened from the inner surface of the pupa-case, they acquire their peculiar coloring, and, the pupa-case bursting upon the back, the perfect insect comes out in all its beauty. At first the wings, however, are shorter and narrower than afterwards, when they have been expanded, stretched, and moved to prepare for their final function. Sometimes, before being hatched, the process of these last changes may be noticed through the skin of the pupa, which grows more transparent in proportion as it is loosened from the surface of the insect within. A row of variously colored dots in *Danais Archippus*, for instance, points out the position of the wings, as well as their extent. In this butterfly the pupa-case is particularly transparent. The colors show most distinctly through the envelope thirty-six to forty-eight hours before the perfect insect comes out, and, in general, a change of color of the pupa is an indication of its advancing maturity. In some degree the perfect wings are folded, but they actually grow, as well as expand, soon after the butterfly has left its pupal envelope, and begins to lead that particular life for which it has undergone these changes. It is now ready to pair, and, after fecundation, to lay its eggs, by which the species is preserved, reproduced, and perpetuated.

III. Special Classification of Lepidoptera.

In the preceding pages we have described minutely the transformations of Eudamus Tityrus within the egg, up to its perfect development as an active butterfly. We have shown that many points in the development of this animal have been entirely overlooked, and that, in general, one stage of the metamorphoses of Lepidoptera has remained, if not entirely unknown to entomologists, at least unappreciated in its bearings. The study of these metamorphoses in the new light in

which it is now presented to us has led to an extensive comparison between these changes of the butterfly, and the permanent states and features of the different families of Insects; and, from this comparison, the necessity of extensive changes in the classification of Insects has been shown, and an entirely revised system, resting upon these new views, has been proposed.

There are now further consequences, following easily from the facts already mentioned, which remain to be traced to their full extent. We have shown the influence the knowledge of these metamorphoses must eventually have upon the classification of Insects at large. We have now further to investigate the bearings of these facts upon the special arrangement of Lepidoptera among themselves, and also to trace out the analogies between those changes of the Lepidoptera and the permanent characters of the other classes of Articulata. For it is not enough to have shown that the classification of Insects has to be modified upon this evidence; we must investigate with equal thoroughness the importance of these facts with reference to the relative position of the different classes which have been distinguished among Articulata in general, and also trace the immediate consequences of a more complete knowledge of the transformations of Lepidoptera, as bearing upon their special arrangement.

Let us first examine the relations of these facts to the special classification of Lepidoptera among themselves. This family, or order, of Insects is generally divided into three natural groups, Diurnal, Crepuscular, and Nocturnal; or Butterflies, Hawk-moths, and Moths; which divisions are by some reduced to two, Diurnal and Nocturnal Lepidoptera, — the Sphinges being then considered simply as a family among Moths, and not as a primary division in the whole order. The question now arises, in what succession these families should be placed, whether we consider the larger groups or the minor subdivisions. Of course, I do not feel prepared to express a decided opinion upon every doubtful point in the classification of Lepidoptera, but simply inquire into the principle of their classification, and try to obtain some light respecting their gradation, from the facts observed in Eudamus. It is generally considered that diurnal Lepidoptera rank highest, and Sphinges are invariably placed between Butterflies and Moths. I have, however, looked in vain, in all the works upon Lepidoptera with which I am acquainted, for arguments intended to justify and sustain this arrangement; and though this order of succession is universally admitted, I do not find that it is anywhere expressly sustained, or that allusion is anywhere made to the evidence that they ought to be considered in that succession, and that this arrangement is intended to express the true relative position of these families. It seems as if this arrangement had been introduced simply for the sake of convenience, by common consent, without having resulted from an inquiry into the subject; or perhaps it has been adopted in consequence of the more extensive knowledge early observers have had of the diurnal Lepidoptera, and from the great difficulty in obtaining and studying the minor species among the nocturnal ones. But whatever may be the cause of this arrangement, so much is plain, that, as soon as the question is raised about its value, it will be found to be still unsettled. I do not, however, oppose the present arrangement. On the

contrary, I am about to show that it is natural, that it agrees with inductions derived from embryological studies, and that it is sustained by facts from various quarters, though some of these facts have remained unnoticed and others have been used unconsciously, or, at all events, never with a view to establish the proper rank of Lepidoptera among themselves.

There is one point in the early metamorphoses of Lepidoptera which is of great importance in this respect; I mean the condition of the larva of diurnal Lepidoptera. Among this family, there is not one species known with maggot-like caterpillars; they are all provided with various kinds of organs of locomotion, legs and prolegs, the last pair of which, again, generally differs from the middle prolegs. They are all colored, and their color is bright and varied. Now this state of development, in which the diurnal Lepidoptera escape from the egg, is already a higher condition than that from which other families among Lepidoptera begin, or of which there are, at least, some examples in various other families. For, even among Sphinges, we have naked larvæ, living in the dark, with an obscure, almost colorless skin. And among nocturnal Lepidoptera the number of those types in which the larvæ are more or less maggot-like is still greater, while among diurnal Lepidoptera all begin with a character of most perfect caterpillars. Again, it is among the nocturnal Lepidoptera that we find the greater number of larvæ resembling Worms proper, or having characters most strongly analogous to those of true Worms.

If, from this state of growth, and the arguments it affords in favor of our view, we pass to the investigation of the pupa, we find here, again, arguments which go to show that the pupæ of the diurnal Lepidoptera have higher characters than those of Sphinges and Moths, as I shall presently show. The caterpillars of Lepidoptera, however highly organized, correspond to that stage of development of Insects in general which we call their larval state, and this homology may be traced through the whole class, however diversified the larvæ of various orders may be. This larval condition corresponds to the state of structure characteristic of the class of Worms. The larvæ of Insects are, indeed, truly homologous to the class of Worms in structure, while their pupæ correspond in the same manner to the class of Crustacea, as I shall show more fully hereafter. If this be the case, let us now compare the pupæ of the different families of Lepidoptera.

Among the nocturnal species, even including the Sphinges, we have those in which the body is smooth, more or less cylindrical, elongated, the abdomen more free and conspicuous, the thorax and head shorter; while the pupæ of all Papilionidæ are angular, the head prominent, the head-chest proportionally longer than the abdomen, with all sorts of protuberances, projecting angles, and spines, and the abdomen comparatively reduced, — characters which seem to me to indicate a remote analogy between the peculiarities characteristic of the long-tailed and short-tailed Crustacea, the relative position of which has long been determined. If, therefore, the general analogy between pupæ and Crustacea be once granted, the more special relation of the diurnal pupæ and Crabs, and that of Moths and Lobsters, must also be granted, and the superiority of the pupæ of diurnal Lepidoptera over the

nocturnal would be also once and for ever established. This seems very natural, as soon as it has been shown that the caterpillar of the diurnal Lepidoptera already ranks higher, on the whole, than that of the nocturnal ones. And this being the case, we are naturally led to expect that the next stage in the metamorphosis should bring the next stage of development higher also.

These views might seem, at first, sustained by very slight evidence. But let us now further consider the perfect state of development of these different Lepidoptera, and we shall find, not only additional evidence of the view I have taken of this subject, but perhaps still stronger reasons for adopting it. Here, again, I wish to call attention anew and more emphatically to another point in the development of Eudamus, and the diurnal Lepidoptera in general.

The position of the wing of the perfect butterfly differs widely in its matured condition from its position in the pupa, and to this point entomologists have paid far too little attention, if they have at all noticed the fact. In all Sphinges and Moths the upper surface of the wings is always turned sideways and upwards, the wing being rolled downwards upon the sides of the larval body; when hatched from the pupa-skin the wings are spread horizontally, or more or less sloping downwards, in the same relation to the body which they had within the pupa, the lower surface of the wings resting upon the body, the upper being turned outwards. There are various modifications in the disposition of these parts: the wings in some sloping more sideways, and still encircling the body as in the pupa; in others being spread flat and horizontally to a greater or less extent, the upper wing, however, overlapping the lower wings very extensively, and almost always covering them wholly in the state of rest, as is the case within the pupa-skin.

Such, however, is not the position of the wings in diurnal Lepidoptera. In the mature stage of growth they are raised above the body, the upper surface being turned upwards and inwards, and never turning outwards or sloping downwards; the upper wings spreading in a manner which leaves the under wings uncovered, and neither pair of wings bending downwards, to encircle more or less the body, as is seen among so many of the moths.

But this disposition of the wings, this character of the perfect butterfly, this mode of carrying their organs of locomotion when at rest, or in activity, is peculiar to the Papilionidæ only in their perfect state. In their pupa condition the wings are placed precisely as in all other Lepidoptera. They are bent downwards, the upper wings covering the lower ones, and the upper surface of the latter being turned sideways. And as no one can doubt that this change in the position and characters of the wings in the diurnal Lepidoptera is something which grows out of a condition common to all, it is as plain as any other embryological evidence can be, that the development of diurnal Lepidoptera goes beyond what is observed in Sphinges and Phalænæ. Assigning, therefore, to diurnal Lepidoptera, upon mature comparison, a decidedly superior position in their order, the Skippers, Hesperidæ, would rank next, from the circumstance that they raise the anterior wings only, and stretch the lower ones more or less horizontally.

My special knowledge of Lepidoptera is not at present sufficient to carry this

view through all the minor divisions of the whole order. I trust, however, that I have here introduced a sound principle, by means of which the closer relations of the secondary groups of Lepidoptera may be determined. This much can already be said, — that the degree of inclination of the wings backwards and downwards, and their greater or less extension sideways, indicate the gradation in which the various types of this order should follow each other. For, when unfolding, the wings of diurnal Lepidoptera, which are at first turned backwards, are next stretched sideways before they are raised. In accordance with this fact, the Sphinges, which stretch their wings sideways, and in which the upper wings do not fully cover the lower wings, should rank next to the Papilionidæ, and be followed by Bombyces, Noctuæ, and Geometræ; and the small Pyralidæ, Tortrices, and Tineæ, in which the wings are constantly stretched backwards close to the body, which they encircle more or less, should really rank lowest, as they are generally placed in our entomological works.

What I have said of the wings may be applied to the legs and trophi. From careful examination of the caterpillar and pupa, especially during its transformation from the caterpillar state into the pupa state, and from this into that of the perfect insect, the relative perfection of these organs will be as easily ascertained as that of the wings.

I may add, that the antennæ should be examined in their earlier stages with equal attention; for they are much more uniform in the pupa state, among all families of Insects, than in their perfect condition. I have already been very much struck with the fact, that the antennæ in the pupa of diurnal Lepidoptera are not yet clavate, as they are in the perfect insect, but resemble rather the antennæ of Sphinges, and, in some instances, those of Phalænæ. But my want of knowledge of the special characteristics of Lepidoptera forbids me to enter, at present, into a more extensive and comprehensive comparison.

IV. Remarks upon the Metamorphoses of some Dipterous Insects.

It is well known that the maggots, which are hatched from the eggs of the meat-fly, and other allied species, undergo no moulting, — that is to say, do not cast their skin during their growth, as the larvæ of most insects do, but preserve, throughout their larval condition, the same exterior envelope, which, in the full-grown larva, is at last contracted, hardened, and transformed into a case similar to the envelope of the common pupa.

This analogy has seemed sufficiently strong to induce entomologists to give the name of *pupa* to that condition of the growing fly; and simply to distinguish it from an ordinary pupa under the name of *pupa coarctata.* These pupæ are sometimes called *cased pupæ*, because they are cased within the skin of the larva. It is further known, that after a certain time perfect flies issue from such pupæ. It would seem, therefore, that the metamorphoses of the Diptera differ considerably from the metamorphoses of other Insects, and that the perfect insect is directly developed under the skin of the larva, without the transition of the worm into a true pupa.

The fact, however, that flies, when hatched from their hard envelope, are often observed to carry after them a thin membranous film, has induced me to inquire more minutely into this case. Having secured a large number of so-called pupæ of the meat-fly, *Musca vomitoria*, I tried to separate their outer coat as soon as it began to harden, and it was probable that the process of further separation of the future perfect insect from its primitive envelope had commenced. I succeeded without much difficulty in tearing off the hard case without damaging in the least the soft animal within, when I found that there was really a true chrysalis * formed under the larva-skin, differing only from ordinary pupæ in the softness of its envelope, which is a simple, transparent, white membrane, presenting in a rudimentary condition all the peculiarities and characteristics which distinguish the perfect fly, but in an imperfect state of development, and very similar to the condition of the young butterfly when it is ready to cast for the last time its larva-skin before it passes into the state of a real pupa.

This transparent chrysalis of the fly shows, like the young pupa of the butterfly, all the parts of the head; rudiments of wings, in the form of short vesicles; three pairs of legs, tubular, unarticulate, bent under the thorax; and distinct joints of the body, already contracted and combined in such a manner as to define in their general outline the head, chest, and abdomen. But that this is a real chrysalis within the larva-skin, and that the difference between the Diptera and the other insects which undergo complete metamorphoses consists simply in the circumstance that the skin of the larva is retained to protect the soft pupa, may be positively concluded from the fact that, within this transparent pupa, we may see, as soon as it is completely separated from the larva-skin, the next stage of development more or less advanced, and the perfect insect appearing within that thin covering. The transparency of the pupa-skin very much facilitates the investigation; as it is easy to see through it all the parts of the perfect insect fully developed at a very early period of the hardening of the larval skin. A week had scarcely passed after my larvæ had ceased to be movable, when, on removing the outer larval covering, I could not only distinguish the perfect pupa, as I have described it above, but within it the well defined parts of the perfect insect, with all their minute characters, could also be satisfactorily distinguished. The legs, which in the pupa were simple, tubular, and unarticulated, were now seen within, with all their joints, hairs, and hooks. The vesicles first representing wings now contained perfect wings, with their nervules and hairs. The eyes with all their facets were well defined. The antennæ also, and all the parts of the mouth, had lost their larval appearance, and assumed the character which they exhibit in the perfect insect. The surface of the rings of the body presented, throughout, the hairy covering and the scales which characterize them, though all these parts were still white, transparent, and entirely soft.

As a striking analogy between the pupa of the fly and that of the mosquito, I may add, that the pupa presented on the sides of the interior part of the thorax

* See also Dr. Harris's Report on the Insects of Massachusetts injurious to Vegetation, pp. 14 and 403.

two little horn-like processes, communicating with the thoracic tracheæ, which are, no doubt, analogous to the two respiratory thoracic tubes of the larva of Culex.

These facts seem to me important, not only as showing a greater analogy in the metamorphoses of different insects than has been supposed to exist, but also as affording greater facilities for the study of the transformation of the pupa into the perfect insect than is afforded in other families, where the pupa itself is hard, and prevents the investigator from tracing the final changes which the insect undergoes within its mummy-like envelope while assuming its last forms. But upon this point I am not, at present, prepared to offer further remarks, and would only call the attention of entomologists to the facilities thus afforded for investigation.

V. Relative Position of the Classes of Articulata.

It is a very strange circumstance, that, in the classification of articulated animals, so little attention has been paid to the metamorphoses as a guide to lead us in our investigations, that comparative anatomy alone has been appealed to for a decision in this question, and that the facts brought forward upon anatomical evidence should have led to an arrangement differing so much from that to which embryology would lead.

It will be remembered that all anatomical zoölogists and all comparative anatomists without exception have considered the Crustacea as highest among Articulata, on the ground of higher structure; being probably influenced by the presence of a heart and the extensive circulation which exists in Crustacea as compared with Insects in which the dorsal vessel faintly reminds us of a heart, and the circulation is so peculiar as to have escaped notice until lately. This inference from anatomical data has, probably, been made under the influence of an old view, from which it is so difficult to divest ourselves, that animals should form a natural series, and may be arranged in one progressive line according to the gradation of their structure. The all-important distinction, introduced by Cuvier, of different types, of four distinct plans of structure, has not yet sufficiently penetrated the spirit of those who have followed in his steps. These four types are not universally acknowledged as independent; they are not constantly viewed as centres radiating in different directions, as they ought to be. Their relative connection with each other is more generally considered than their peculiarities as distinct types. For, if these great divisions of the animal kingdom were fully understood as distinct types, it would follow naturally in the mind of every one, that what might be a character of superiority in one group might not be so in the other; what might lead to natural combinations in one department might mislead in the estimation of relations in another; and the final impression would be, that in each type there is a peculiar ruling principle, which must be considered by itself; and that we are not allowed to bring the four types into connection with each other, unless upon the most general considerations, when investigating the foundation of animal life in its different general tendencies, and comparing these tendencies with each other to find out their common foundation as well as their difference. But as soon as we enter into any

details, as soon as from these generalizations we begin to investigate the peculiarities of each type, then let us be guided by special principles, and no longer by the general abstract laws of life.

Now, in the type of Articulata, we have division of the body, articulation of the limbs, development of joints, external evolution of parts, and multiplication and independence of these parts, prominent in every type under most diversified modifications; and these peculiarities characterize the type of Articulata. External metamorphosis is, perhaps, on the whole, the most prominent feature of this type; that is, extensive changes in the external appearances of the body, — changes which follow in regular succession at definite periods of life, and introduce successively such modifications in some of these animals, in which the metamorphosis is most extensive, as completely to alter their appearance; so much so, that only direct observation of successive generations can satisfy us that, under these different forms, we have really the different stages of growth of one and the same animal. The study of these changes of form is the more important, as the structure changes at the same time; for here changes of the form and of the structure are so closely related as to be simultaneous.

Now it is a principle which must be acknowledged universally, that in the growth of animals their successive changes are progressive, — are steps forwards, — an advance from a lower to a higher condition. However evident the decrepitude of old age may be in the structure of an animal, as long, at least, as it grows and successively assumes new changes, we cannot for a moment suspect that these changes are retrograde steps in the organization. This must be granted even in the presence of the deformed appearance and extreme growth of pregnant individuals, or of females preparing for reproduction, among parasitic Crustacea. For here we observe a kind of metamorphosis which has no longer a direct bearing upon the growth of the individual, but has reference to its reproduction. I insist upon this point, as otherwise the principle of progressive development might be questioned even in its fundamental consequences.

But as soon as it is granted that the young animal is less perfect than the mature one, as can be shown by tracing its development from the egg, it will follow as a matter of course that the metamorphoses of Articulata, considered in general, must be the safest guide to a just appreciation of the relative position of the secondary groups in the whole type. The most perfect metamorphoses are known among Insects. They appear in their caterpillar, pupa, and perfect state. But these metamorphoses have various degrees in different families. The larvæ of all Insects are not equally advanced when they are hatched from the egg. In some, the larva comes out as a naked, colorless worm, without any appendages; in others, it has simple legs of one kind; in others, there are various sorts of legs, and the body is variously colored and provided with external appendages; in others, the larval development takes place altogether within the egg, and the young insect is hatched in the form of the parent, wanting only wings. But in all these different conditions the larva is, undoubtedly, inferior to the pupa. The pupa state of Insects is the period of their development which, at the present time, stands most in need of further investiga-

tions and extensive comparisons; for it is not now very well understood, nor is its character fully and justly appreciated.

From its appearance among Lepidoptera, it is generally represented as a dormant state in the development of the young butterfly, as a sort of mummy almost without life; while, in reality, it is a period of the most extensive organic activity, during which the greatest changes are going on in the structure preparatory to the appearance of the perfect insect. When the butterfly leaves the pupa, it undergoes no further organic change; all the changes took place chiefly during the period when the caterpillar was transformed into a pupa, and during the pupa state itself. This stage of growth is therefore to be considered as one of the most important periods in the development of the insect, just as the growth within the egg is with reference to the caterpillar. The homogeneous cellular mass which constitutes the egg gives rise to the caterpillar; when hatched, it is already fully developed as a caterpillar, and grows only to a larger size as such; but its structure, as far as it is characteristic of that state, is introduced during the metamorphosis of the substance of the egg from which it arises, in the same manner as the perfect insect is formed from the changes which the caterpillar undergoes under its last skin, and during the earlier part of its pupa state. These are the two great periods of development; the other periods are periods of growth. The caterpillar feeds upon large quantities of food, grows to a larger size, and stores up large quantities of organic matter, out of which, by another extensive metamorphosis, the perfect insect is developed; which, when mature, lives only to reproduce its kind. Up to that period the development is decidedly progressive, and up to that period we see even those articulated animals which undergo a so-called retrograde development advance in their metamorphosis from lower to higher structures, from a simpler to a more complex organization.

Now, are not the insects which undergo the most extensive metamorphoses to be considered as the standards from which the forms of other articulated animals have to be appreciated? Is not the fact, that caterpillars bear so close a resemblance to Worms, a sufficient indication that the Worms rank lower than Insects? No serious objection can be made to this principle; and if so, may not the relative position of Crustacea between Worms and Insects be determined upon the same principle? It can be shown that we have no other safe guide to determine the true relation between the different classes of articulated animals.

Let us first compare, more fully, the larval condition of Insects with adult Worms. And here I cannot but regret that the larvæ of Insects have not all been so carefully studied as those of Lepidoptera, and more minutely described and figured than they are in our entomological works; for, generally, all that is given there has mere reference to their general form, and even the external parts are not always described and figured with sufficient accuracy. It seems as if a knowledge of the external forms only were to be acquired; and as if the morphology and structure of the parts in their successive changes were of no consequence to the appreciation of the affinity of animals before they have attained their final development. However, we find among Insects larvæ entirely destitute of external appendages, the body consisting of several uniform joints, and the head being scarcely distinct from the other articu-

lations. In the aquatic species of that kind, there are external, gill-like, respiratory organs, while in the terrestrial ones the respiration takes place through stigmata and tracheæ. In others the head is more developed, the joints of the body less uniform, appendages to some joints are developed, and the whole larva assumes more fully the appearance of a terrestrial animal. In a higher condition still, we see these larvæ brightly colored, the head well distinguished, peculiar feet attached to the anterior rings of the body, and feet of another kind to several posterior joints; larvæ of this description begin to resemble the perfect insects which are developed from them, in almost every respect save that they are destitute of wings. In numbers of them there are, in addition to the legs, appendages developed upon all the rings of which the body consists, which give them a most remarkable appearance. Now, if we take into view all these different forms of larvæ throughout the class of Insects, without reference to the peculiar types of winged insects which arise from them, and institute a comparison between them and Worms, we cannot fail to be struck with the remarkable analogy which exists between them. The naked larvæ correspond to the naked Worms, and the larvæ provided with appendages resemble the Dorsibranchiate and Tubulibranchiate Worms in so close a manner, that particular genera of Worms might be singled out as corresponding most closely to different forms of larvæ among Insects. The larvæ of Limacodes, for instance, can be considered as terrestrial representatives of the genus Polynoë; the larvæ of Bombyces correspond to the Nereid Worms, while some among the larvæ of Papilio proper, with their protractile branching appendages upon the neck, remind us of Terebella. It would seem as if the larvæ of Lepidoptera began their life in a condition analogous to that of the higher Worms, and as if they had no analogy to the lowest types of Worms, that is, to the Helminths or Intestinal Worms. However, this were a very incomplete view of the subject, for these larvæ within the egg show a still lower organization, and forms and structures which are as closely analogous to the forms and to the structures of Intestinal Worms as those of full-grown larvæ are to the higher Worms.

Now the special characters of Worms as a class consist precisely in the peculiarities which distinguish the caterpillar from the perfect insect. Their body consists of numerous uniform joints, the head being scarcely distinguished from the body, or, at least, the head only being distinguished, — the appendages to the joints being diversified equally upon all the joints, or entirely wanting, and wings never being developed upon them in any of their stages of growth. Further analogies might be traced, there being Worms with external gills, as we notice among certain larvæ of insects; others, the Earthworm for instance, with aerial respiratory organs, as are most larvæ of Insects. Some are entirely blind, others provided with many ocelli. The internal structure also might be compared, with the same results; but it will suffice to hint at it, to recall at once to the minds of zoölogists and anatomists the difference which exists between the internal structure of larvæ and that of the perfect insect, and the resemblance the larvæ show, on the contrary, to the structure of Worms.

The question respecting the position of Crustacea among articulated animals is

one of greater difficulty. There is something imposing in the larger size, in the greater strength, in the powerful appendages, in the perfect circulation, of crabs and lobsters, and I do not wonder that, from these inducements, so many naturalists have been led to the idea that Crustacea rank highest among Articulata. But there are also among these animals so many of an inferior size, almost microscopic, and with so simple structure, especially among the parasites, that there is no reason for being too strongly impressed by the superior size of the smaller number. But let us examine what is the value of these characters, and how we should compare the Crustacea to other articulated animals to arrive at rational conclusions.

As a class, Crustacea are characterized by an arrangement of their joints which is peculiar to them. The single rings of which their body consists are no longer uniform. They may be similar, they may be free, but there is always considerable difference between them, and they are always provided with locomotive appendages of some kind or other. There is scarcely a type among them so low as most Worms; and I venture to say that there is no one among them which ranks as high as Insects. For in Crustacea, whatever be the diversity in the joints, they are all more or less provided with locomotive appendages; these animals all breathe with gills, and the development of the circulatory apparatus is, in all, in accordance with this particular mode of breathing, as it is a general fact, that gill-breathing animals have a well supplied circulation of blood. We need only consider the Fishes, and even the Gasteropoda and Cephalopoda, or compare the Worms provided with gills with those which breathe in a different way, to be satisfied of the fact. So that, in my opinion, the development of the circulation in Crustacea is no absolute indication of their higher rank, and we shall be still less disposed to assign to them so high a position, as soon as we examine them in a morphological point of view.

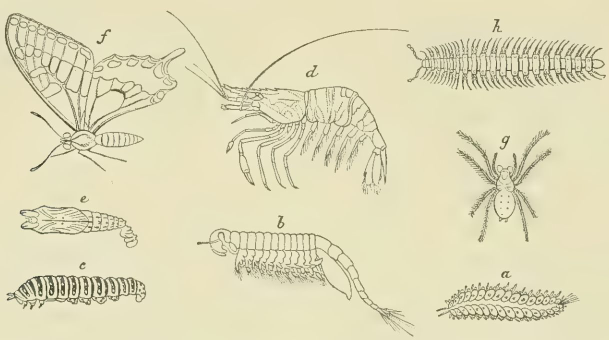
It is well known that their body consists of a number of joints, which is frequently larger than the number of joints in Insects, and even larger than that of the larvæ of Insects, coming, in this respect, nearer to the Worms than to the Insects, in whatever state we may compare them together. A larger number of joints among articulated animals is so constant a character of inferiority, that we must not overlook this important fact, when inquiring into the natural position of Crustacea. Again, these joints are more extensively free than they are among Insects, — nearly as much so as among Worms, — or they are soldered into a solid box, as in Crabs; while there is no perfect true Insect in which the joints are not combined into three distinct regions, head, chest, and abdomen. Moreover, the joints in Crustacea are all provided with locomotive appendages; in Insects they are so only in the larval condition, and the locomotive appendages are reduced in number, and confined to the chest, in their perfect state; for even the claw of a lobster resembles more the paddle of its tail, than the true legs of an insect larva resemble its prolegs. The jaws of Insects undergo such changes, that they assume forms and functions differing far more from those of the legs than among Crustacea, in which various pairs of the masticatory apparatus have still the common form of legs. Their other appendages, such as the eyes and antennæ, are also in Insects more remote from the common type of such appendages than they are among Crustacea. So that

there is a distinct inferiority of development in all these respects among Crustacea when contrasted with true Insects, which should leave scarcely a doubt in our minds that this class as a whole is inferior to the class of Insects as a whole.

But there is another point in this question which, in my opinion, settles definitely the relative position of Crustacea between Worms and Insects. Wherever the joints of their body unite to form distinct regions, they combine in such a manner as to form only two well-defined divisions: the tail, or rather abdomen, with free, movable joints, and the rings of the head and chest, united into one continuous shield above, though below they may present more or less distinct indications of their primitive separation. Head and chest united, and abdomen free and movable, with morphologically homogeneous appendages upon all the joints, — such is the character of the highest Crustacea. Now, in the development of true Insects we have a stage of growth when these animals assume precisely the same condition. It is that of the pupa. Before the insect assumes its final winged state, the rings of the anterior part of the body are soldered together more closely, and the abdomen alone remains free and movable. The lower wings, with a somewhat gill-like structure, which, for a time, are free in the young pupa, are soldered upon the inner surface of the upper wings, which themselves adhere to the chest. The jaws and legs are almost identical, and it may be said that a pupa corresponds, in its main features, to that combination of characters among Articulata which is peculiar to the Crustacea. Indeed, what is the pupa among Insects? It is that state in their development in which the anterior joints, which were free in the larva, are fused into one distinct region, no longer endowed with free movements; but in which the joints of the abdomen still remain movable. This answers most remarkably to the structure, form, and adaptations of the body of Crustacea. And this being the case, I consider the position of the whole class as settled. It is intermediate between Worms and Insects; for, in the general development of Insects, the pupa state, which corresponds to the Crustacea, is the intermediate state between the worm-like larva and the perfect insect. Worms, therefore, are the lowest class among Articulata, the Crustacea the next class above, and Insects the highest class of that type. Of course, in this arrangement we give up all possibility of bringing the higher type of Articulata in any way near the lower types of any of the other great divisions of the animal kingdom, with which it might seem natural to combine them in one continuous series; as, for instance, with the lowest of the Vertebrata. But such attempts are precisely what I have objected to in our classifications; while, upon the arrangement I propose, the type of Articulata in all its peculiarities is gradually wrought out more and more fully, and in its highest class recedes most from all other types. The impossibility of combining the type of Articulata, by its highest families, with any of the other types, I consider as one of the most valuable features in my classification. I know very well that some of the Annellides have been mentioned as constituting a link between Articulata and Vertebrata through the Myxinoids. But who would, in the present state of our knowledge, place Annellides above Insects and Crustacea, because they have colored blood, when their relation to Helminths is so plainly ascertained? It seems to me far more rational to trace the

analogy which exists between the lowest families of all the four great types of the animal kingdom, and to consider these different types as rising from a common base, in four different directions, to different heights of development, at which they differ most widely. The analogy between the lowest Worms, with their embryonic characters, the lowest Polyp-like Mollusca, and the lowest Radiata, is a far more prominent feature in the animal kingdom than the collateral analogies which exist between their higher families.

There is another feature in the affinities of the articulated animals, which, in this classification, is more fully brought out, and which otherwise can hardly be traced, — the fact that the lower Crustacea resemble Worms nearly as much as the young Insects; and that here, again, we have in the three classes of this type a repetition of the leading feature which we have noticed when comparing the four great types together, — the Worms beginning with a worm-like form, which they preserve through life, — the Crustacea beginning with a worm-like form, or with worm-like inferior types, rising in their highest families to the type of pupæ, — and the Insects beginning with a worm-like form, transforming into pupæ, or, in other words, assuming temporarily the type of Crustacea, and attaining finally to their highest state, that of winged Insects.



The wood-cut here annexed will give a graphic picture of this correspondence. Fig. *a* represents Polynoë squamata, as a type of the class of Worms. Fig. *b* represents Branchipus stagnalis, as a type of the lower Crustacea, exemplifying at the same time their analogy to the Worms and to the larval condition of the higher Crustacea, of which Fig. *d* represents a characteristic species, the common shrimp of Europe, Palemon serratus. Fig. *c* represents the caterpillar of Papilio Asterias, which has a close resemblance to some of the higher Worms of the family of Tubicolæ. Fig. *e* represents the pupa of the same Butterfly; its analogy to the higher Crustacea, which consists in the combination of the rings into two distinct regions, cannot be overlooked. Finally, Fig. *f* represents a perfect Butterfly, in a state of development which is not attained by any type of the great division of Articulata except Insects.

At this stage of the investigation, I venture to say that I have myself already traced, to some extent, the analogy which exists between the various forms of

pupæ and the different types of Crustacea, and that I have satisfied myself that it will successively be found more and more intimate, and give finally to this classification the character of a true genetic natural arrangement.

With reference to the class of Insects, there are some particular points which require especial study. It is well known that among air-breathing Articulata there have been several classes distinguished under the name of Insects proper, Arachnidians, and Myriapoda, and there are several groups intermediate between the two latter, which stand almost isolated, and were formerly united under the common name of Aptera. The question now arises, how these are to be regarded with reference to the true Insects, and whether they should form intermediate classes between Crustacea and Insects, or be united with the Insects proper as one class.

As far as the Arachnidans are concerned, I entertain no doubt that they cannot be considered as a class by themselves, but must be decidedly united with the Insects; for the peculiarities in their structure upon which the separation rests hardly justify such a primordial distinction. The difference, as it has been given, is chiefly derived from the number of legs, and from the respiratory apparatus; there being in the true Insects only three pairs of legs, while in Spiders there are four, and the respiratory organs of Insects being true tracheæ, and those of spiders lung-like sacs. But this greater number of locomotive appendages indicates only a lower degree of structure, rather than a classic difference. Again, the difference in the structure of the respiratory organs is rather morphological than essential, as Dr. R. Leuckardt has recently shown. So that the chief ground for a distinction of the Spiders as a class is illusory. But there is a far more important difference in the circumstance, that in Spiders head and chest are united; and this corroborates the inferiority which an additional pair of legs ascribes to them among Insects. Spiders, indeed, should be considered as pupa-like Insects in a perfect state of development, not undergoing a further growth, but assuming, in that stage of progress, their final development as perfect animals. The greater resemblance of their jaws and antennæ to legs would also sustain this view.

As for the Myriapoda, we can consider them as caterpillar-like Insects, in which the respiratory organs, the masticatory organs, and the organs of locomotion, assume their final growth, under a worm-like form, and the whole body presents true entomological characters at a period of development when it still preserves the form of a larva with many joints, with legs upon all the joints, and the head only distinct from the other rings, but resembling Insects in their antennæ, in their compound eyes, in their articulated feet, in their stigmata, and in almost every detail of internal structure. This resemblance is even so close to the structure of some Coleoptera, that one is almost tempted to view the Brachelytra as a connecting link between this lower order of Insects and the Myriapoda. Fig. *h* of the foregoing wood-cut, which represents a species of Polydesmus, will show this analogy between Myriapoda and the larva of Insects, as well as with the Worms and lower Crustacea, and Fig. *g*, which represents a Spider, Salticus scenicus, will show the corresponding analogy between this group of Articulata and the pupa of Insects, as well as with the higher Crustacea. In the highest class of Articulata, including Myriapoda, Arach-

nidæ, and other Aptera, and true Insects, we have thus, with the organization of Insects proper, a repetition of the natural forms of the three classes of the type. We have worm-like Insects, the Myriapoda, — Crustacea-like Insects, the Spiders, — and true Insects, with wings, and six legs; or, in another point of view, larva-like Insects, Myriapoda, — pupa-like Insects, Spiders, — and true Insects, above all; the larval and worm-like condition being both expressed in the form of Myriapoda, while the pupa-like and Crustacea-like form is shown in the Spiders, and the true Insects, as the highest stage of development, rank above all. So that the special classification of Insects proper, again, sustains the general classification of Articulata, in which we have ascribed the lowest rank to Worms, the intermediate position to Crustacea, and the highest to Insects.

EXPLANATION OF THE PLATE.

Fig. 1. Egg of Eudamus Tityrus, natural size; Fig. 1^a, enlarged in profile; Fig. 1^b, enlarged from above; Fig. 1^c, a rib of the same egg still more enlarged.

Figs. 2, 3, 4, 5, and 6. Larvæ of Eudamus Tityrus, in different stages of growth.

Fig. 7. Pupa of the same; Fig. 7, the pupa in its loose cocoon, with the larva-skin cast at its side; Fig. 7^a, the pupa seen in profile; Fig. 7^b, the same seen from above.

Figs. 8, 9, and 10. The larva before casting its last skin.

Figs. 11, 12, and 13. The larva casting its last skin, and the pupa coming out; seen in profile, Fig. 11, from above, Fig. 12, and from below, Fig. 13.

Figs. 14, 15, 16. The pupa entirely detached from the larva-skin, which hangs behind the abdomen; Fig. 14, seen in profile; Fig. 15, from above; Fig. 16, from below. The wings, legs, antennæ, and trophi are entirely free.

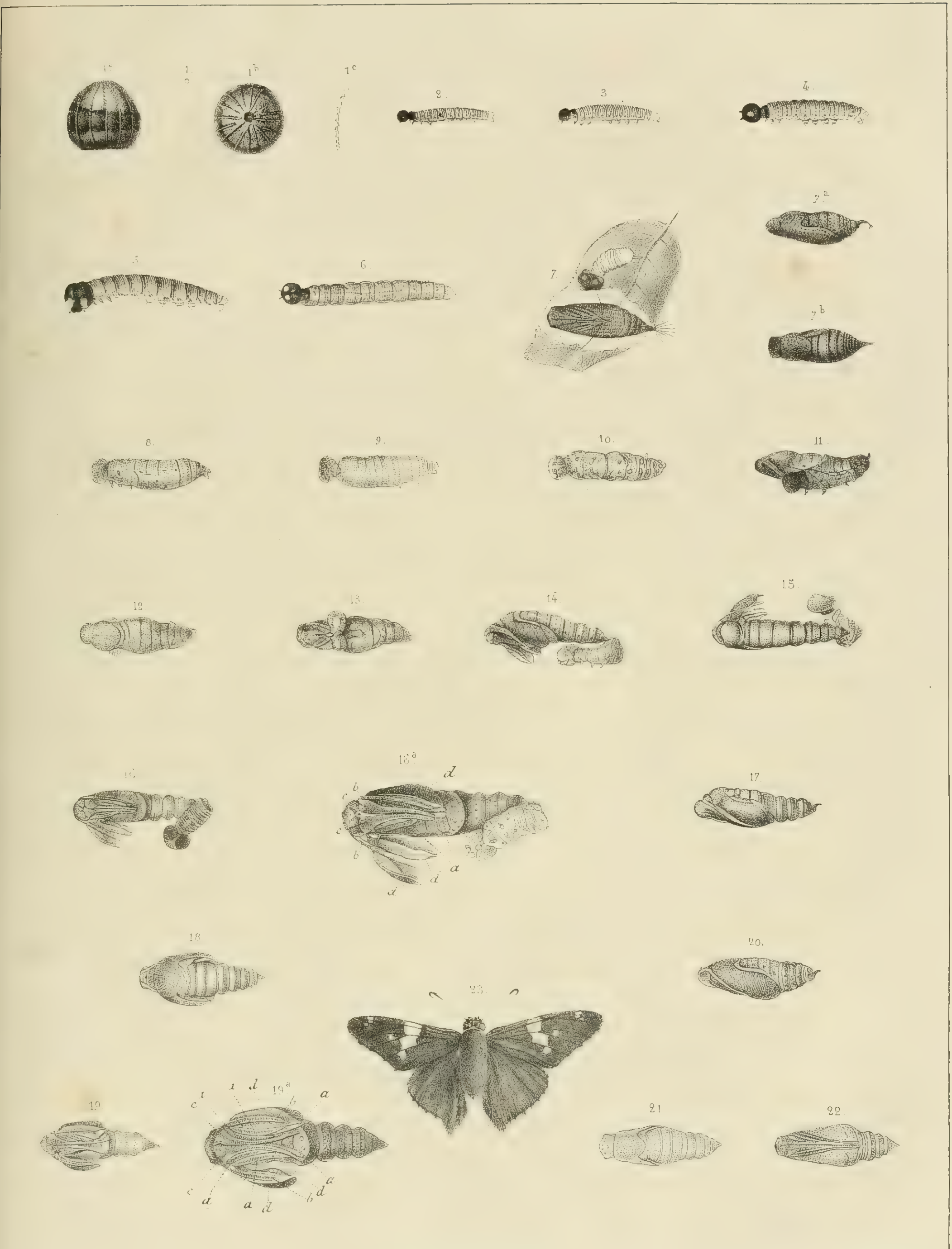
Fig. 16^a represents the same pupa as Fig. 16, somewhat enlarged; *d d* being the vesicular wings, *c c*, the jaws, *b b*, the antennæ, and *a*, the legs.

Figs. 17, 18, and 19 represent the pupa entirely freed from the larva-skin, and somewhat more advanced than in Figs. 14, 15, and 16; the wings, antennæ, and trophi being, however, still free.

Fig. 19^a represents the same pupa as Fig. 19, somewhat enlarged; *d d* being the vesicular wings, *c c*, the jaws, *b b*, the antennæ, and *a a a*, the legs.

Figs. 20, 21, and 22. The pupa nearly perfect; the wings being flattened upon the sides of the body, and beginning to adhere to the chest, as also to the antennæ, trophi, and legs. Fig. 20, seen from the side; Fig. 21, from above; Fig. 22, from below.

Fig. 23. Eudamus Tityrus, in its perfect state of development.



J. Burkhardt from nat. Tappan & Bradford's lithy. A. Sonrel on stone

EUDAMUS TITYRUS

MEMOIR

ON THE

EXPLOSIVENESS OF NITRE,

WITH A VIEW TO ELUCIDATE ITS AGENCY

IN THE

TREMENDOUS EXPLOSION OF JULY, 1845, IN NEW YORK.

BY ROBERT HARE, M.D.,

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ACCEPTED FOR PUBLICATION

BY THE SMITHSONIAN INSTITUTION,

OCTOBER, 1849.

COMMISSION

TO WHICH THE MEMOIR HAS BEEN REFERRED.

DR. JOHN TORREY, M. D.
COL. J. J. ABERT, *U. S. Top. Engineer.*

PRINTED BY EDWARD O. JENKINS,
114 Nassau street, New York.

MEMOIR

ON THE

EXPLOSIVENESS OF NITRE.

SUMMARY.

Statement of the Phenomena and Facts of the Great Explosion.—Attributed to Gunpowder.—This disproved by competent Witnesses.—Failure of the Chemists employed by the City Government to produce an Explosion by Mixtures of Nitre with Combustibles, and their consequent Report against the explosive Efficacy of Nitre.—Opposing Opinion of respectable Chemists, especially Silliman and Hayes.—Experiments of the latter, showing that Nitre may explode with Water, confirmed by an Explosion which had happened in the Author's Laboratory.—Illustrative Reference to the Explosion consequent to the Combustion of Potassium upon Water.—Explosiveness of Nitre with Substances containing Water or Hydrogen, ascribed to the Affinity of Water for Bases being at a high Temperature, greater than that of Nitric Acid.—Discrimination between explosive Combinations of which the Ingredients are held in a State of Contiguity by chemical Affinity, and pulverulent Mixtures mechanically aggregated; compression being requisite to Explosiveness in the one Case, but not in the other. —Chemical Affinity, in the Case of Potassium oxidized and intensely heated upon Water, performs the Part of mechanical Force in the Explosion of Moisture by the Impact of incandescent Iron.—Nitre exploded with Sugar under incandescent Iron simultaneously struck with a Sledge.—Force of the Impact thus produced, less than that, for an equal Area, resulting from the dancing of 700,000 pounds of Merchandise upon 300,000 of incandescent Nitre within the Walls of the exploded Store.—Impossibility of exploding Gunpowder or Gun-Cotton in Vacuo.—Products of the Combustion of these Compounds ascertained and compared; also their projectile Power, which for equal Weights makes that of Gunpowder to Gun-Cotton, nearly as one to four; while the gaseous Products are as one to three nearly.

1. Among the conflagrations by which cities have been more or less devastated, there has been none, it is believed, of which the phenomena were more awful and mysterious than those of the great fire which took place in the city of New York, on the 19th of July, 1845.

2. The destruction of two hundred and thirty houses, containing merchandise amounting in value probably to two millions of dollars, made the calamity in question highly deplorable as a cause of pecuniary loss and embarrassment; while the characteristics which gave to it an unprecedented rapidity of extension, were of a nature to excite an enduring interest as well as temporary consternation.

3. A series of detonations, successively increasing in loudness, were followed by a final explosion of which, agreeably to an affidavit, the report resembled a "*loud clap of thunder.*" This tore into pieces the building within which it took place, threw down seven houses in the vicinity, and drove in the fronts of the houses on the opposite side of the street, at the distance of eighty-seven feet. The whole of the space within which these tremendous effects took place, was filled with a dazzling flame, and various masses, intensely ignited and vividly luminous, were projected aloft as if expelled from a volcano, so as, on alighting, to spread the conflagration far and wide. Shipping anchored in the Hudson River, probably at the distance of more than a quarter of a mile, were greatly endangered by these deflagrating missiles.

4. So violent was the atmospheric concussion, that people were prostrated by the consequent blast, when too remote to be injured by the flames or flying fragments. Some persons were wounded or killed, but so small was the number, in comparison with that of the multitude which might have been mutilated or destroyed, that there was more gratulation for the escape of the many, than sorrow over the few who actually perished. This comparative immunity was due to the warning given by the detonations which, as already mentioned, preceded that by which the mischief was effected.

5. The natural inference arising from the detonations thus alluded to, was, that gunpowder had been stored in parcels of various amounts on the different floors of the store, the smaller portions above, the larger below, and that the detonations were the consequence of the successive ignition of the parcels thus situated. The cry of gunpowder was raised on the occurrence of the first explosion, and caused the retreat of almost everybody near the quarter whence it proceeded. Hence before the final catastrophe, the streets about the store were entirely vacated, so that scarcely any person was injured besides those in the houses opposite to the conflagration.

6. Notwithstanding the reasonableness of the belief at first created, as to the agency of gunpowder, there was the most conclusive evidence, so far as the oaths of worthy and well-informed witnesses could avail, that no gunpowder was contained in the building within which the explosions occurred. Of course, the real cause of the disaster became a subject of perplexing consideration for chemists in general, and especially for those adepts in chemistry, to whom the Corporation of the city concerned applied for an elucidation of the mystery.

7. It was fully established by the statements of the highly respectable proprietors, and that of their store-house clerk, that there were in the store more than three hundred thousand pounds of nitre, secured in double gunny bags, containing one hundred and eighty pounds of nitre each, in piles alternating with heaps of combustible merchandise; yet as, agreeably to ordinary experience, such combustibles deflagrate when ignited with nitre, without exploding, this did not remove the unfavorable impressions unjustly created respecting the occupants of the store. The stowing of any large quantity of gunpowder adequate to the effects produced, had been culpably imprudent and illegal; and coupled with a most solemn denial

on their part, would have involved them in the baseness of falsehood, if not the guilt of perjury.*

8. To everybody the elucidation of the mystery was desirable, since, without a correct knowledge of the causes, the proper means of guarding against a recurrence of such explosions could not be devised. It was interesting to men of

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* "The contents of the store, agreeably to the evidence of the clerk, whose business it was to keep an account of them, were as follows :—

In the cellar there were :
58 hogsheads of sugar.
16 barrels of molasses.
6 cases of indigo, four covered with gunny bags, two cases without gunny bags.
8 cases of lac dye—one case open, and seven not open.

First floor :—
About 300 or 400 bags of saltpetre, in double gunny bags, one bag outside of the other.
About 8 casks of madder.
About 5 bales of hides.
5 bales of safflour.
32 bags of mustard seed.
3 ceroons of Guayaquil hats.
1-2 chaldron of Cannel coal (Liverpool). Weighing geer.
A small lot of loose kindling wood ; about half a load.
4 desks and contents.
1 water-closet.
Small bags containing samples of saltpetre.
Samples of shellac, and a lot of books.

Second floor :—
About 1000 bags of saltpetre, and another lot of sumac.
150 boxes of sugar.
21 bales of raw silk.
Between 8000 and 9000 cigars, in half boxes.
2 casks of indigo.

Third floor :—
About 530 bags of saltpetre, in the same condition as that on the first floor.
Between 20 and 30 bales of gunny bags.
About 700 bags of coffee.

Fourth floor :—
Filled with coffee in bags. There was nothing else there.

Fifth floor :—
7 bales of gunny bags.
125 cases of shellac.
Some 15 or 20 pieces of fur.

Garret :—
About 200 bags of coffee."

The following summary, giving the weights, has been furnished to me by Messrs. Crocker and Warren.

science to have it ascertained wherefore their efforts to produce an explosion by similar ingredients, were unsuccessful.* To the occupants of the store it was important, since they were liable not only to ill opinion and legal prosecution as above stated, but likewise to a deprivation of their claims for insurance. Fortunately for them, in opposition to the opinions and experimental inferences of several chemists who were consulted, tending to extend or confirm the idea, that gunpowder, illegally and most culpably stored, must have been the cause of the catastrophe, the opinions of Silliman and Hayes, and other eminent chemists, were called forth, tending to sanction the inference that the result might be due to the reaction of nitre with contiguous merchandise.†

9. I owe it to my friend, Augustus A. Hayes, to state, that I might have adopted the more general impression, had it not been for his inferences and experiments made with the view of accounting for the explosion of a vessel, loaded with nitre, while lying at anchor in the harbor of Boston. It was ascertained by this able chemist, that when, by an experiment made in his laboratory, between one and

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By this it appears that there were in all more than a million of pounds of merchandise in the store, of which about one-third was nitre.

RECAPITULATION.

150 boxes and 58 hogsheads Sugar, gross weight,	127,183
16 barrels Molasses,	8,182
23 cases Indigo,	7,028
14 " Lac dye,	3,468
1799 bags Saltpetre,	347,207
1-2 ton Cannel Coal,	1,200
8 casks Madder,	13,176
32 bags Mustard seed,	5,213
299 " Sumac,	48,701
6 bales Hides,	4,102
5 " Safflour,	1,526
10 bundles Twine,	1,806
21 bales Raw Silk,	3,242
33 " Gunny bags,	16,079
3232 bags Coffee,	391,049
136 cases Shellac,	41,968
	1,021,040
Nitre,	347,207
Merchandise,	673,833

* With means furnished by the Councils, five eminent chemists made several experiments upon a large scale, in order to ascertain the effect of igniting nitre with such combustibles as were associated with it in the store of Messrs. Crocker and Warren; yet in no instance could they produce detonating reaction. The activity of the combustion never surpassed that degree of rapidity and consequent violence which may be designated by the word deflagration.

† The opinions of Silliman were given at length in a Report submitted to a Committee of the City Council, at whose instance it had been prepared.

two hundred pounds of nitre, intensely heated in a crucible, were suddenly sprinkled with water, an explosion ensued.*

This statement of Hayes caused me to recollect, that upon one occasion a mischievous explosion had occurred in my laboratory, when a fissure taking place in

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* The subjoined quotation from the Boston Daily Advertiser, will serve to show the point to which Mr. Hayes had attained, in elucidating the mysterious explosions produced by incandescent nitre, when my efforts to afford a further elucidation commenced. It seems, from the language of the editor, quoted below, that the cause of the explosion, in the store of Messrs. Crocker and Warren, had been previously a subject of discussion in his newspaper, the conflagration having occurred a short time previously.

"EXPLOSIVENESS OF SALTPETRE.

"The following correspondence contains the information in reference to this subject, to which we alluded in our paper on Saturday. The statement of Mr. Hayes, we conceive, can leave no doubt that the saltpetre in the store of Messrs. Crocker and Warren, at New York, surrounded as it was with combustible materials, and exposed to the water thrown from the engines, was the cause of the explosion which has been the subject of so much discussion, and that it is quite unnecessary to suppose that there was any gunpowder in the store." * * * * * * *

The following particulars are stated by Captain Cotting, of the ship Virginia, of the burning of that ship on the fifth of May last. This ship contained a cargo of linseed and saltpetre. In his letter, published in the Newburyport Herald, he says:

"In about ten minutes from the time the fire was first discovered, the after hatch blew off, and at the same time the fire forced its way through the ship's side, on the starboard quarter, a short distance from the water-line. In about ten minutes from this time, the boats having been got out, the crew, feeling the deck rising, jumped into the sea, and succeeded in getting into the boats, cut the painters, and shoved off Almost at the same time an awful explosion took place, the fire rising to the height of 200 feet from the main and after hatches, and a few seconds afterwards from the fore hatch. At the same time the main and mizen masts went by the board. Five minutes from this time, the ship disappeared with all her cargo. In twenty-five to thirty minutes from the time the fire was first discovered, no trace of the ship was visible. All that was saved was two boats, chronometer, sextant, and one compass."

Boston, 25th *July*, 1845.

A. A. Hayes, Esq.:

Dear Sir,—Our mutual friend, Mr. Ralph Smith, informs me that you have made some experiments with a view of ascertaining whether, and under what circumstances, saltpetre, when ignited, will produce explosions.

Much curiosity exists at this time in the community upon this subject, and divers opinions have their advocates. To me it seems strange that among our numerous scientific men and professed chemists, no one has stood forth, sustained by nice experiments, with a view of settling this much-vexed question.

Perhaps you have already satisfied yourself in the matter. If you have, you will greatly oblige me, and the public, by furnishing for publication the results of your investigations. If you have not sufficiently investigated already, I beg of you the favor of instituting such a course of experiments as will throw the much needed light upon the subject.

I am, respectfully,
Your obedient servant,
Henry Williams.

Roxbury Laboratory, 28th *July*, 1845.

Henry Williams, Esq.:

Dear Sir,—Your note of yesterday, in relation to the explosive action of saltpetre, has this moment come to hand. I most cheerfully comply with your request in placing

an iron alembic holding about twenty pounds of fused nitre, on hoisting the alembic off the fire, a jet of the liquefied salt fell accidentally upon some water in a tub, which was unfortunately too near. It also brought to mind that potassium, when thrown upon the surface of water, is, by combustion with the oxygen of that liquid, converted into a fused globule of red-hot oxide, which, in the act of combining with water, detonates violently. This detonation struck me as being clearly owing to a sort of double reaction, in which, while one portion of water, by uniting with the oxide of potassium, converts it into hydrate of potash, another portion, uniting with the heat, flies off explosively as steam.

10. In a letter to Hayes, immediately after his explanation appeared, I stated these

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before you the facts connected with the subject of the action of saltpetre on substances usually called combustible.

Saltpetre, or the nitrate of potash, or soda, *alone*, does not burn, or explode by heat, however intense. It parts with one of its constituents, oxygen, by heat, and it is to the combination of its oxygen with other bodies that it owes its power of burning with them. Wood and other fibrous substances do not burn with saltpetre until they have become partially charred; they then produce *deflagration*, or burn with sparks. A large quantity of saltpetre, enclosed in gunny bags, as it is usually stored, after fire was communicated to it, would burn with the bags, emitting much smoke and sparks, precisely as paper which has imbibed saltpetre would. It would not be consumed; only the small quantity required to burn with the bags would be changed. If an addition of burning wood or charcoal were made to the extent of one-fifth the weight of the saltpetre, an intense and continued deflagration would result, and all the saltpetre would be changed. *No explosion would follow from applying fire to mixtures of charcoal, or wood and saltpetre;* the rapid combustion called deflagration would be produced, but, unlike explosion, time would be required for the mutual actions; and where the quantities were large, many hours would be necessary before they would cease. The recent destruction of life and property in New York, the loss of a homeward-bound Indiaman and her cargo, by a similar cause, have created an anxiety which has led to many inquiries respecting the origin of the *explosions* attending the burning of saltpetre. I need not remind you of a case which occurred at Central Wharf, about ten years since, when the Hartford Packet was destroyed. The testimony obtained in the last instance led me to make some experiments on the effects produced by dropping water on a burning mixture of saltpetre and charcoal. It was ascertained that a very small weight of water, relatively to the saltpetre, caused explosions, which might be made successive, so long as the materials remained. The quantities of the substances acting, being increased to between one and two hundred pounds, the addition of water, in the form of spray, caused an explosion which destroyed the vessel, and shook all the buildings in the vicinity. The temperature of a burning mixture of saltpetre and charcoal, at the points of contact, is superior to that of "white hot" iron, and the form is that of a bubbling fluid. Water falling on the mass is instantly converted into steam, having the elastic force of that used in steam-guns; exceeding gunpowder in destructive energy. The red-hot particles, dispersed by the sudden action, pass over considerable spaces, and the appearance of flame is produced.

In cases where water falls on highly heated polished surfaces, such as melted glass, copper, or silver, steam is formed rapidly, but silently; the water does not touch the hot surface. The spreading of a film or crust over the polished surface, instantly alters its relation to water, and causes steam to form with explosive violence, attended by a loud report.

I do not hesitate in expressing my belief, that the disastrous effects produced in New York were caused by water or other fluid falling on saltpetre, while burning with the bags investing it. The facts which I have stated may have interest or importance in connection with attempts made to extinguish fire in buildings containing saltpetre. The danger of throwing water on the fire is manifest, while the loss to the owner of the saltpetre would doubtless be greater from water than from fire.

Respectfully, A. A. Hayes.

facts and inferences; and moreover, I endeavored to illustrate the subject by referring to the explosion so frequently produced by blacksmiths, through the forcible contact with moisture, of incandescent iron struck by a hammer. It has been ascertained that globules of oxide of iron, as they fall in a state of fusion from a wire ignited in oxygen, do not at first produce any commotion in water. This arises from the generation of a protecting atmosphere of rarefied aqueous vapor, which renders contact with the liquid water impossible. Widely different would be the result, were the liquid suddenly forced into contact with the globule by a blow from a hammer, as above mentioned. Analogous causes operate when globules of the most volatile liquids or solids are retained for a time in the cavity of an incandescent metallic ladle, meanwhile evaporating much more slowly than if the temperature were less. In any one of these instances an explosion would follow from a contact being coerced between the heated surface and the liquid. When a hammer is employed as above described, mechanical force produces that contact, which, in the explosive union of incandescent oxide of potassium with water, is caused by intense chemical affinity.

11. The explosion produced by Hayes, as above mentioned, and that which took place in my laboratory, as well as the explosive reaction of oxide of potassium with water, gave a practical confirmation to the inference, that the meeting of water with the base of incandescent nitre could cause tremendous results. Subsequently, in the winter of 1845–6, I found that when nitre, by the flame of a hydro-oxygen blow-pipe supplied with atmospheric air and oxygen, is heated to incandescence, and then quickly submerged in water previously situated beneath the containing ladle, a sharp explosion ensues. I found, nevertheless, that when thrown, under like circumstances, upon molasses or sugar, the effects were those of deflagration rather than explosion. Yet, latterly, I have fallen upon contrivances, by which pulverized sugar and nitre may be made to explode. The first expedient which succeeded, was that of pouring melted sugar upon the face of a hammer, so as to make a disk of commensurate size. Such a disk, if it should not adhere, is easily made to do so by slightly moistening the face of the hammer. Some nitre was put into a thin shallow platina capsule, situated over a small anvil, near one of its edges, so that the bottom of the capsule might be reached obliquely by a hydro-atmospheric blow-pipe flame. Under these circumstances, the nitre having been heated until its potash began to be volatilized, was struck with the sugar-faced hammer. A smart detonation was the consequence. This experiment may fail sometimes from the blow not being properly given; from the nitre not being sufficiently hot; or the capsule being ill situated. The explosion of fulminating mercury by a hammer fails sometimes, from the blow not being so given as to produce a due degree of parallelism between the surfaces.

12. Another method of producing explosive reaction is as follows:—Nitre and sugar being coarsely powdered, let disks of paper, about three inches in width, be prepared. Place one of the disks upon an anvil, and cover it with a stratum of sugar. Then cover the sugar with a stratum of nitre, placing over this another of the disks. Heat a flat iron bar, wider than the disks, to a welding heat, and quickly withdrawing it from the fire, and holding it above the paper, strike it down

thereon with a sledge. An explosion will ensue, with a very loud report. Of course the operator's face should be protected by a mask, his hands and legs by a leathern or woollen apron, and gloves. The operation may be performed by one person, but more advantageously by two, as it is difficult for one to hold the iron in the position most suitable for bringing the surfaces together with the requisite degree of parallelism.

13. In a letter in reply to one from Mr. Durant, of New York, respecting the explosions which are the principal objects of these communications, I adverted to the superiority of the affinity which exists between water and oxide of potassium over that which exists between nitric acid and the same base,* as a reason why the presence of the elements of water, or of hydrogen in union with carbon, should, on ignition with nitre, give rise to explosive reaction. Obviously, the consequence of the displacement of nitric acid by water must be, that the gaseous constituents of the acid, incapable of remaining in combination without a base, would escape, either as nitrogen, nitric oxide, or oxygen gas, or, carbon being present, partially, as carbonic oxide, or carbonic acid.

14. Gum, sugar, starch, and lignin, consist of carbon in union with the elements

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* It may be well here to advert to the fact, that one of our young countrymen, Tilghman, has, without any hint from me, not only perceived the property of water on which I have insisted, but likewise has had the sagacity to suggest its application in various useful processes. These have all been founded on that superior affinity of water for certain bases, on which, in my letter to Hayes, I had insisted as affording the rationale of the explosion of nitre either with this liquid, or with any substance containing its elements.

From the preceding suggestions, and some experiments, of which an account will be subjoined, it appears that the explosive violence of a mixture of nitre with substances containing carbon in union with hydrogen, or with hydrogen and oxygen, so as to be competent to convert the base into a hydrate or carbonate, is dependent on the force with which they may be held or brought together in a state of ignition, being sufficient to permit of that increase of temperature which is necessary to explosive reaction.

Probably at the temperature thus alluded to, the ingredients are all in a condition analogous to that of a very dense explosive gaseous mixture. It is well known that such mixtures detonate with a velocity apparently not less than that of an electrical discharge. A single electrical spark, a particle of platina sponge, even a sunbeam, may cause an explosion so instantaneous, that it is the collapse only that can be observed. The dilatation which precedes the collapse escapes scrutiny. However large the volume, ignition in any one part seems to affect the whole at once.

I infer, then, that when, nitre and certain compounds of carbon with hydrogen and oxygen, reach a temperature at which the whole mixture, if not restrained mechanically, would take the aëriform state by a sudden revolution in the electro-chemical polarities, that detonating combination ensues, to which, when ignited, various gaseous mixtures are liable. A few cubic inches of olefiant gas, with twice the bulk of oxygen, included in soap-bubbles and inflamed, will produce a report equal to that of a musket. The accidental explosion of a half gallon of a similar mixture created a thundering noise like a field-piece, so as to alarm the whole neighborhood within a furlong of my laboratory.

Aware of the influence of confinement in augmenting the force of reaction between nitre and combustibles, the distinguished chemists above mentioned (as having been called upon by the Corporation of New York to investigate the phenomena under consideration,) treated the absence of this condition as a reason for discrediting the idea that the reaction of nitre with combustibles could account for them. But agreeably to the facts, I propose to show that there must have been a mechanical force in operation sufficient to bring the matter into a state analogous to that which enables fulminating combinations, or explosive mixtures of gas, to detonate either from ignition, from exposure to an electric spark, or, in some instances, from a blow or catalysis; in other words, from some influence like that exercised by platina sponge.

of water, being virtually hydrates of carbon. Oils, resins, or bitumens, consist of carbon and hydrogen, with but little oxygen. Of course either, when heated with nitre, can supply water to the base of this salt, *with*, if not *without*, assistance from its oxygen, which constitutes nearly half of the matter in nitre. Such substances may, therefore, under favorable circumstances, perform the part performed by sulphur in gunpowder, which I conceive to be that of seizing the potassium and liberating the acid, so as to enable its oxygen to react freely with the carbon and the resulting sulphide of potassium. Considerations analogous to those advanced respecting the agency of the elements of water in exploding with nitrates, will apply with respect to those of carbonic acid; since carbonated alkalies, no less than the hydrated, being indecomposable *per se* by heat, carbon as well as hydrogen must, by uniting with one portion of the oxygen of the nitric acid and taking hold of the base, expel all the nitrogen with the rest of the oxygen.

15. Having submitted the preceding facts and considerations, my explanation of the stupendous explosion which forms the topic of this communication is as follows:

Of the enormous quantity of nitre which the store held, more than 56,000 pounds were on the first floor, about 180,000 pounds on the second floor, and about 100,000 on the third floor. The weight of combustible merchandise was about 700,000 pounds. As it was alleged by some of the witnesses examined that the iron window shutters of an upper story became red hot by the conflagration of an adjoining house, it is probable that fire was communicated to some of the gunny bags holding the nitre, or some other combustibles, which, as stated in evidence, were piled against the shutters. As soon, however, as a single bag became ignited, the nitre with which the inner bag must have been imbued, would give the greatest deflagrating intensity to the consequent combustion; while the interstices between the bags, like those between grains of gunpowder, would enable the flame to pervade the whole heap of bags. As nitre fuses at a low red heat, very soon a great quantity, in a state of liquefaction, must have run down upon the wooden floor, which would immediately burst into an intense state of reaction with the oxygen of the salt. To this combustion the merchandise adjoining would add fuel, causing a still more extensive liquefaction of the nitre. The deflagrating mass thus created, on burning its way through the floor, or falling through the scuttles, which were all open agreeably to the evidence, must have received an enormous reinforcement from the subjacent nitre or combustible merchandise. On the giving way of each floor in succession, the conflagration must have received a reinforcement of deflagrating fuel, so as to have grown rapidly with its growth, and strengthened with its strength. Under these circumstances, the whole of the nitre becoming liquefied, must have found its way to the cellar. Meanwhile, the merchandise and the charcoal of the wood-work must have been conglomerated by the fusibility of the sugar, shellac, and bitumen, aided by the molasses, and formed thus an antagonistic mass of more than half a million of pounds in weight, deflagrating intensely with the nitre. But whenever, by these means, a portion of the deflagrating congeries attained the fulminating temperature, a detonation must have ensued, causing a temporary lifting of the

combustible mass; only, however, to be followed by a more active collision, resulting from the subsequent falling back of the conglomerated combustible mass upon the melted nitre. After every such collision, the combustible congeries must have been blown up to a height augmenting with the temperature, the force of the fall, and extent of reciprocal penetration. The force of the fall would, of course, be as the height. Hence the twelve or thirteen successive detonations indicate as many explosive collisions; while the successive augmentation of the loudness of the reports indicates a proportionable growth of their violence, arising from successively greater elevation and descent.

16. If I am right in supposing that in fulminating power, the intensely heated nitre and the combustible merchandise were for equal weights equivalent to gunpowder, if only a sixth of the 300,000 pounds of nitre held in the store was engaged in the final explosion, it would be equivalent to sixty thousand pounds of gunpowder.

17. No better way of estimating the force with which the nitre and combustibles were brought into collision for the last time, at which the finishing explosion took place, has occurred, than that of comparing it with the blow by which nitre and sugar were exploded as above mentioned, in one of my experiments.

The weight of the combustible matter contained within the store was 700,000 pounds. The store was ninety feet deep by twenty-four wide. Supposing the horizontal area of the sledge as applied, to have been $3 \times 3 = 9$ square inches, it seems that for every equivalent horizontal area within the store, there must have been twenty-two pounds, or about three times the weight of the sledge. Hence, in descending from a height of twenty or thirty feet, which there was ample room for it to reach, the combustible congeries may have attained a much greater velocity than could be imparted to the sledge, and may consequently have produced a much more forcible impact. At the same time, this must have caused an intimate penetration and intensity of compression, which by a dead weight it is almost impossible to create.

This explanation, so far as it rests upon the assumption that the combustibles were made to dance upon the surface of the melted nitre, is supported by the fact that any combustible mass, when thrown upon the surface of incandescent nitre, will undergo a dancing motion, so as sometimes to leap out of a deep pot within which the experiment may be made.

The phenomena are not irreconcilable with the idea that some of the earlier explosions arose from the falling of the liquid nitre upon the combustibles before all the floors gave way; but it should be recollected that nitre fuses at a low red heat, and at a cherry red gives out oxygen gas. The presence of this gas, as well as the deflagration resulting from contact with the liquid nitre, must have caused the floors to be oxidized with a rapidity far exceeding that which takes place during ordinary conflagrations.* To the causes of quick destruction thus suggested, must be added the mechanical force of the explosions directly at war with

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* See Note to paragraph 9.

the persistence of the floors. That, prior to the last explosion, the nitre must have been collected in the cellar, may be assumed from the fact, that the temperature being inevitably far above its fusing point, the salt must have been all liquefied, and occupying the lowest accessible cavity, on account of its superior specific gravity. This assumption is moreover justified by the circumstance that the force of the explosion appears to have been especially exerted upon the parietes of the cellar, the walls and surrounding earth having given way in a manner which created astonishment.

19. In order to amplify the practical basis upon which the preceding inferences had been founded, I made some experiments on the combustion of gunpowder in an exhausted receiver, so as to secure the gaseous products evolved. A cylindrical glass receiver, such as is usually employed as a candle shade, was ground upon a lap-wheel, so as to fit air-tight between two disks of sheet brass. The disk for closing the upper opening of the receiver was furnished with two cocks severally, for communicating with an air-pump and barometer gauge. The disk for closing the lower opening of the receiver, so as to form the bottom of the space included, was furnished with an arch of platinum wire soldered to two stouter brass wires, of which one was soldered to the disk, the other secured and insulated in passing through it by a collet of leather, compressed about it by an appropriate screw. These preparations being made, a portion of gunpowder, weighing about 25 grains, was so supported on a tray, as to include the middle portion of the platinum wire. The receiver being put into its place, so as to be duly supported by the lower disk and covered by the other, the air was withdrawn as far as practicable, with a good air-pump. In the next place, the wire was ignited to incandescence. To my surprise, the gunpowder only smoked at first, and did not flash until a perceptible interval had elapsed. When this result ensued, it appeared to be owing to the radiant heat, as the early volatilization of a portion of sulphur had driven the granules away from the wire, so that it did not touch any of them. Subsequently, on allowing the air to enter, and removing the receiver, it appeared that the gunpowder was only partially burned. Thus it became evident that in this way a complete combustion could not be effected. The feebleness of the flash in vacuo shows how much confinement is essential to give energy to the explosion of this powerful agent, and its not being forthwith ignited by an incandescent wire, demonstrates that, as in the case of the apparent quiescence of a globule of volatile matter in an intensely heated cavity, a capability of volatilization delays this process, by preventing the contiguity requisite to a communication of heat.

20. This leads to a discrimination which has not, to the best of my knowledge, been made heretofore. I allude to the difference existing between fulminating *combinations* and fulminating *mixtures*. As an example of the latter, we have gunpowder and other pulverulent mixtures consisting partially of nitre, or chlorate of potash, while, as an exemplification of the former, we may advert to aurum or argentum fulminans, or to the fulminates of mercury or silver; also to the chloride or iodide of nitrogen, or perchloric ether. Compounds of the last-mentioned kind, without confinement, break the vessel on which they are exploded. They cannot be used in gunnery, because the force in their immediate vicinity, in proportion to its durability, is too great, so that they burst the chamber before the

ball moves an available distance. The elements in these combinations are in a state of intense chemical union, and can only leave that state for another, by which gases and vapors are produced with an instantaneous and almost irresistible expansibility. They require no confinement, because already confined by their reciprocal affinities. In gunpowder and analogous mixtures, the ingredients exist without any forcible coherence, so that an incipient reaction causes a tendency to move apart, which prevents the reaction from extending itself when there is no confinement. This was strikingly shown by attempting to burn in vacuo a small cylinder of consolidated gunpowder, made by intense pressure within a metallic tube by a steel piston. This cylinder, about a half inch in diameter and an inch in length, was placed in contact with a platinum wire within an exhausted receiver. The wire being ignited, a feeble combustion ensued. Subsequent examination showed that the cylinder was only about half deflagrated, the unburnt portion remaining unchanged. It had been extinguished spontaneously, after being completely ignited at the end in contact with the incandescent wire.

21. This was, no doubt, in consequence of the process being effected in a rarefied medium. In order to compare these observations with those which might be made by combustion in pleno, I made a larger cylinder of gunpowder, two inches in diameter and two inches in height, by similar means, and set fire to it by an iron rod ignited at one end. This I caused to touch the top of the cylinder while standing upright at the bottom of a cast-iron pot about four inches in diameter, and a foot in depth. The combustion very much resembled that of a rocket, commencing feebly, however, yet terminating with a deflagration so rapid as to be almost explosive. The augmentation of intensity, I ascribe to the increased resistance from reaction with the gas evolved, which pressed upon the cylinder with a force like that which elevates a rocket.

22. Finding that, in vacuo, a perfect combustion could not be accomplished by the means above mentioned, I resorted to an arrangement through which a cylinder of consolidated gunpowder might be so supported by a rod sliding in a stuffing box as to be pushed upwards against a wire ignited by a galvanic battery within an exhausted receiver. When, by these means, the ignition of gunpowder was attempted, it was not very readily accomplished. The part touching the wire appeared to burn feebly; nevertheless, by turning the rod so as to cause the cylinder to revolve, and consequently to be assailed at various points, combustion was induced and gradually extended, and at last completed satisfactorily.

23. The receiver employed was held between two metallic plates, one forming the bottom, the other the cap. Through the middle of the bottom the sliding rod was introduced, so as to be in the axis of the cavity. It was secured by two stuffing boxes, the object of the outer one being to enable the rod to pass through the orifice of a vessel of oil, employed to prevent the possibility of air entering through that next the cavity. The juncture of the cap with the receiver was covered by cold water, which served to prevent leakage, and keep down the temperature. This was ascertained by a thermometer within the receiver, yet accessible to inspection. The cavity, thus secured against leakage, held 240 cubic inches; the contents being indicated by a column of mercury in a barometer tube

situated before a scale graduated into 480 parts. Of course, the whole contents being 240 cubic inches, as above stated, each graduation represented half a cubic inch.

24. The igniting wire was soldered to the ends of brass rods, of which one was soldered to the cap, the other secured by collets of leather, so as to pass through the cap without metallic contact. Consequently, connection being made between this insulated rod and one pole of a battery, while the other pole had a metallic communication with the cap, the wire might at any moment be made the medium of a circuit competent for its intense ignition.

25. The upper end of the sliding rod supported a little disk of sheet copper, and a little below that disk was supported, in like manner, a larger disk of the same material perforated like a colander.

26. Upon the upper disk, the consolidated gunpowder being supported with all the above-mentioned arrangements, the receiver was replaced.

27. The air was withdrawn until the mercury in the gauge tube attained nearly the height of the column within an adjoining Torricellian tube, or that of a neighboring barometer. The height was recorded, likewise the temperature indicated by the thermometer. The fall of the barometrical column of mercury in the gauge tube, resulting from the operation, was not estimated until the mercury in the thermometer was in statu quo. The difference in degrees caused in the height of the barometric column, divided by two, gave the number of cubic inches of gaseous matter evolved. This difference was of course set down.

28. In the next place, the temperature being carefully observed and recorded, about two cubic inches of a strong solution of caustic potash was added. The consequent absorption, as it declined in rapidity, was assisted by an agitation consequent to moving up and down the rod, and the perforated disk attached to it. When no more absorption could be observed to take place, judging by the quiescence of the mercurial column in the gauge, and when the temperature had returned to the starting point, from which it had been disturbed by the heat generated through the reaction between the alkali and carbonic acid, the height of the column was again recorded, and the difference of degrees, divided by two, were estimated to give the number of cubic inches of carbonic acid generated. Allowance was made for the mechanical effect of the bulk of the alkaline liquid in lowering the mercurial column founded on actual measurement of the effect of a like quantity of water; the mercury being brought to the same height in the gauge tube, in an experiment made for the purpose with atmospheric air.

29. Three samples of Dupont's powder were obtained from the United States Arsenal, severally designated cannon, musket, and rifle powder. Of each, 75 grains were pressed into an indurated cylindrical mass, as above described, and successively burned in the exhausted receiver.

The following are the results :—

Cannon powder,	gas evolved,	55	cubic inches.
"	" absorbed,	$23\frac{1}{2}$	"
Musket powder,	" evolved,	52	"
"	" absorbed,	$21\frac{1}{4}$	"

Rifle powder, gas evolved, ...	$51\frac{1}{2}$	cubic inches.
" " absorbed, ...	$20\frac{1}{2}$	"
Sporting powder, average of two experiments,		
Gas evolved, ...	51	cubic inches.
" absorbed, ...	25	"

30. As the gas left after the removal of the carbonic acid had all the negative characteristics of nitrogen, it may be concluded from the results above given, that the gaseous products of deflagrated gunpowder consist of nearly equal volumes of carbonic acid and nitrogen.

31. I was naturally led to compare the results of the deflagration of gun-cotton with those of gunpowder. Accordingly, I exposed a tuft of gun-cotton, weighing twenty-five grains, in the exhausted receiver in a similar way. I found a retardation in the activity of the combustion arising, as in the case of gunpowder, from the absence of mechanical confinement, diminution of atmospheric pressure tending to lessen the contiguity indispensable to intense chemical reaction.

32. The deflagration of the tuft being effected, it caused an evolution of gas equal to $19\frac{1}{2}$ cubic inches.

33. In order to concentrate the combustible ingredients, resort was had to the apparatus employed in the case of gunpowder, by which means twenty-five grains of the cotton could be condensed into a cylinder of about half an inch in width, and of a like length.

34. Two specimens of gun-cotton, of the manufacture of Lennig, of fifty-four grains each, prepared and ignited as above described, gave an evolution equal to $126\frac{1}{2}$ cubic inches.

35. As seventy-five grains of gunpowder gave only fifty-five cubic inches of gas at most, it appears that equal weights being employed, gun-cotton causes a gaseous evolution more than three times as great as gunpowder.

36. As seventy-five grains of gunpowder produces, taking the largest amount in the above table, only fifty-five cubic inches of gas, it follows, that to produce an effect equal to fifty-four grains of gun-cotton, one hundred and seventy-two and a half grains of gunpowder would be requisite.

37. The gunpowder evolved little more than seven-tenths of a cubic inch per grain, while the gun-cotton evolved more than two cubic inches per grain.

38. The gas arising from the gun-cotton did not admit of an examination so simple as that given out by gunpowder.

39. By the introduction of one hundred cubic inches of oxygen gas, it appeared from the consequent red fumes, and absorption by water, that about thirty-five cubic inches of nitric oxide had been formed: by the introduction of caustic potash, about twenty-five cubic inches of carbonic acid was indicated. One third of the residual gas being exploded with oxygen, appeared to consist of three volumes of hydrogen to four of carbon vapor. The washings gave indications of cyanogen.

40. The coexistence of nitric oxide, carburetted hydrogen and cyanogen, in the products, justifies the idea, that were the heat greater, the expansive effect would be augmented by the transfer of the two atoms of oxygen in the oxide, to the hydrogen and carbon, producing augmentation of temperature, carbonic acid and

aqueous vapor. In order to bring the explosive power of gun-cotton to its maximum, I infer that immense resistance would be necessary, thus concentrating and expediting the reaction.

41. The residue of the explosion of gunpowder appears, from a qualitative analysis, to consist of sulpho-cyanide and sulphide of potassium, with carbonate and sulphate of potash. The two latter are by much the more abundant products. Probably sulphur is the primary and most energetic ingredient, as when in excess it is, *per se*, known to be capable of completely decomposing potash at a moderate heat, while carbon can only partially effect an analogous change at the highes heat of a furnace. Faraday has recently alleged, that the production of the flame of sulphide of potassium is an important agent in the explosive ignition of gunpowder. It is likely that from the reaction of oxygen with sulphur and potassium, a temperature results sufficiently high for the combustion of the charcoal with oxygen, and of nitrogen with sulphur and carbon, whence ensues carbonic acid and sulpho-cyanogen, in union with potassium in the one case, and with potash in the other.

42. I have already distinguished the explosion of mixtures like gunpowder from fulminating combinations, of which the constituents being held together by intense chemical affinity, require no mechanical confinement nor impact to bring or keep them sufficiently near each other for reciprocal reaction. There is, however, another distinction to be made. The explosion of vessels by high steam is altogether the effect of heat and confinement. The resulting violence, when the vessel bursts, is directly as its strength; so that, knowing how many pounds per square inch the vessel was capable of bearing, we know the explosive force to have been exactly equal thereto. But the strength of the containing vessel, in the case of gunpowder, may be very far short of that generated by the gunpowder ignited within it. When held together until the temperature is attained which is requisite for the play of affinities into which the ingredients are disposed to enter, a sudden evolution of heat and gaseous matter takes place, producing a diruptive force far beyond the retaining power of the vessel.

43. Although gun-cotton is a chemical combination, consisting of nitric acid and lignin, yet it does not explode, when unconfined, with a violence approaching to that of other fulminating combinations above mentioned. This may be attributed to the fact that neither the elements of nitric acid, nor those of lignin, are held together by a strong affinity, and consequently the forces which resist explosion are but feeble.

EXPERIMENT.

COMPARATIVE STRENGTH OF GUN-COTTON AND GUNPOWDER.

Agreeably to some recent experiments made in my presence by Captain Mordecai, of the Regulars, at the U. S. Arsenal, Washington, at about thirty feet distance, a cylinder of gun-cotton, weighing twenty-five grains, condensed as

above described, drove a musket-ball through seven white pine boards, of about an inch inthickness. One hundred and ten grains of gunpowder caused the ball to pass through eight boards of the same target. Two cylinders of gun-cotton of the same size, that is to say, twenty-five grains in weight each, caused a musket to burst. The iron of the musket, judging from its coarse crystalline texture, does not appear to be of the best quality.

These results seem to show, that while the force of gun-cotton, in gunnery, is to that of gunpowder as four to one, the ratio of the quantity of gas generated by the former, to that generated by the latter, is as three to one

The greater quickness of the deflagration of the gun-cotton may be the cause, in part, of this diversity of ratio. Another cause may be, a more thorough combustion. Of a large discharge of gunpowder, some portion escapes unburnt; in the case of gun-cotton, in the form employed in the experiments above mentioned, none escapes.

SUMMARY.

It is an old and well accredited maxim in chemistry, to which there are but few exceptions, that fluidity is requisite to chemical reaction. The fluid state, of which the necessity is thus asserted, is with few exceptions attained only through water, or heat, or both. In truth, however, when it is considered that without heat there could be no fluidity, heat may be viewed as the sole solvent. As respects the induction of the state requisite to chemical reaction, we may consider the solution in which water is the ostensible agent, or igneous fusion in which it is absent, as the only means of bringing the atoms of solids into the state requisite for chemical reaction, through which decompositions and recompositions are effected.

It is well known that the affinities which prevail among the same set of bodies when liquefied by aqueous solution, may be the opposite of those which they exert when indebted to heat solely, for liquefaction. Thus there is scarcely any acid which will not displace silicic or boric acid from alkaline bases when in aqueous solution, yet when salts, consisting in part of the most energetic acids, are fused with silicic or boric acid, decomposition ensues in consequence of the union of the acids last-mentioned, with the bases ignited with them.

The sulphates, carbonates, or hydrates of potash, soda, and of some other bases, are *per se* indecomposable at any heat at which their bases cannot be volatilized; yet the nitrates of the same bases, are decomposed at the temperature of incandescence. It follows that if a nitrate be exposed to igneous fusion with any substance consisting more or less, of hydrogen, carbon, or sulphur, and the oxygen of the nitrate will, by forming water with the hydrogen, carbonic acid

with the carbon, or sulphuric acid with the sulphur, cause the nitrate to be replaced by a hydrate, a carbonate, or sulphate.*

But as in every atom of nitrate, there are, independently of the base, five atoms of oxygen, and since to convert hydrogen into water requires one atom, to convert carbon into carbonic acid requires two atoms, and to effect an analogous change in sulphur requires three atoms, it follows that for every atom of hydrogen there will be four atoms of oxygen liberated, for every atom of carbon three atoms, and for every atom of sulphur, two atoms. Each atom of oxygen is to the weight of nitrate of potash as 8 to 102; hence there will be by hydrogen nearly 32 per cent., by carbon nearly 24 per cent., by sulphur 16 per cent. of oxygen evolved to act upon the excess of the contiguous combustible matter. Meanwhile it must be recollected that gum, sugar, starch, and lignin, (or fibre of wood, cotton, or linen) both hydrogen and oxygen, exist in due proportion to generate water; and besides these compounds formed with oxygen, we have nitrogen to aid,† which is more incoercible than water or carbonic acid. Since at the heat produced by the combustion of hydrogen or carbon, with pure oxygen, iron, the most tenacious of all the materials at our command, is perfectly fusible, it is evident that by mechanism we cannot restrain the expansive force of the gaseous products producible as above represented. I believe, I may say, that water has never been confined under a white heat. Yet the expansive force of liquid carbonic acid is at the freezing point of water, thirty-six times as great as the pressure of this liquid at its boiling point It has already been observed, that nitrogen, in expansive violence must go beyond carbonic acid. It follows, that excepting the blow of a hammer, or the force created by gravitation in falling bodies, we have no means by which we can enable nitre, in the state of incandescent igneous fluidity, to come into close contact, *even for an instant*, with masses of combustible matter, like those which it was made to encounter in the store of Messrs. Crocker and Warren.

It is to be presumed that it has been the want of this force which has caused efforts to produce explosions between nitre and combustibles, to fail; and it is to the presence of this force, where the fall of enormous masses of agglutinated combustible matter upon incandescent liquified nitre, may be reiterated, that I ascribe the destructive explosions, which, under such circumstances, have been so prolific of impoverishment, mutilation, and death.

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* The power of decomposing incandescent nitre by aqueous vapor, which was inferred by me to exis in 1845, has since been fully verified by the employment of this vapor by an American chemist, Tilghman, to effect the decomposition of compounds containing potash, or other alkaline bases capable of forming hydrates, *per se*, indecomposable by heat. (See Note, p. 10.)

† Nitric acid consists of one atom of nitrogen as well as five of of oxygen.

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

MICROSCOPICAL OBSERVATIONS

MADE IN

SOUTH CAROLINA, GEORGIA AND FLORIDA.

BY

J. W. BAILEY,

PROF. CHEMISTRY, ETC., U. S. MILITARY ACADEMY, WEST POINT.

ACCEPTED FOR PUBLICATION

BY THE SMITHSONIAN INSTITUTION,

DECEMBER 1ST, 1850.

VOL. II ART. 8

COMMISSION

TO WHICH THIS PAPER HAS BEEN REFERRED.

PROF. WM. B. ROGERS,

PROF. LEWIS R. GIBBES.

JOSEPH HENRY,
Secretary of the Smithsonian Institution.

PRINTED BY EDWARD O. JENKINS,
114 Nassau street, New York.

MICROSCOPICAL OBSERVATIONS

MADE IN

SOUTH CAROLINA, GEORGIA, AND FLORIDA.

The observations here recorded were made during the winter and spring of the years 1849—50, while on a tour as an invalid through the Southern States. Although my researches were pursued under many disadvantages, and amount to scarcely more than a *reconnoisance* of the places visited, yet some facts of considerable interest were determined; and as the microscopic productions of these regions have never before been studied, some value must attach to even the most imperfect examinations. With this feeling, I offer the following notes, hoping that if they have no other interest, they may serve to point out to Southern naturalists, and the numerous intelligent invalids who hybernate in the South, how rich a field of amusement and instruction surrounds them even in midwinter.

Among the most interesting results obtained were—1st. The discovery of an extensive stratum of fossil Infusoria near Tampa Bay, (see page 19). 2d. The existence of vast quantities of infusorial remains in the rice fields and salt marsh formations of the South, (see pages 5, 11, 12, 13 and 20). 3d. The discovery of many new species of microscopic plants and animals, (see page 36). 4th. The demonstration of the cosmopolite character of many minute beings hitherto only known as European species, (see tables, pages 28, 31 and 33).

For the convenience of those microscopists who may hereafter visit any of the regions which I examined, I will state in detail the circumstances of time and place under which each observation was made, and give for each locality a list of the species, and then combine these into a general table, to illustrate the distribution of species.

SULLIVAN'S ISLAND, S. C.

Dec. 11*th*, 1849.—On the logs and stones of the breakwater, in front of Moultrieville, I found the following forms:

DIATOMACEÆ.

Achnanthes longipes? Ag., forming very long bands, containing 50 to 100 frustules, mounted on a long footstalk. (See fig. 1, pl. 2.)
Amphora Lybica, Ehr.
Ceratoneis fasciola, Ehr.
Ceratoneis closterium, Ehr.
Coscinodiscus lineatus, Ehr.
Grammatophora oceanica, Ehr.
Gallionella sulcata, Ehr.
Navicula sigma, Ehr.
Licmophora radians, Kg.

CHARLESTON NECK.

Dec. 19*th*, 1849.—In company with Prof. Gibbes, of Charleston College, I collected the following forms in a fresh-water ditch near "the Lines," viz:

Bacillaria paradoxa, Ehr.
Synedra valens, Ehr.
Closterium acerosum, Schrank.
Cosmarium undulatum, Corda.
" cucumis, Corda.
" margaritiferum, Turp.
Euastrum ampullaceum, Ralfs.
Penium digitus, Ehr.
Scenedesmus obliquus, Turp.
Docidium nodulosum, Bréb.
Amblyophis viridis, Ehr.
Arcella vulgaris, Ehr.
Euglena viridis, Ehr.
" pleuronectes, Ehr.
Stentor polymorphus, Ehr.

MUD OF CHARLESTON HARBOR.

In mud collected from the logs of wharves, and from other situations in Charleston Harbor, the following species of Diatomaceæ were noticed.

Actiniscus sirius, Ehr.
Actinocyclus bioctonarius, Ehr.
Actinoptychus senarius, Ehr.
Biddulphia pulchella, Gray.
Cocconeis scutellum, Ehr.
Coscinodiscus excentricus, Ehr.
Dictyocha fibula, Ehr.
Eupodiscus Rogersii, Ehr.
*Eupodiscus radiatus, B.
Gallionella sulcata, Ehr.
Navicula sigma, Ehr.
Pinnularia interrupta, Kg.
" didyma, Ehr.
" lyra, Ehr.
Rhaphoneis rhombus, Ehr.
Stauroptera aspera, Ehr.
*Surirella circumsuta, B.
Terpsinoë musica, Ehr.
Triceratium favus, Ehr.
" alternans, B.

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* Species marked with a star are believed to be new, and are described at page 36.

CEDAR HILL, ASHLEY RIVER.

Dec. 15*th*, 1849.—At Mr. Dwight's plantation, (Cedar Hill,) I found growing abundantly on stems of grasses in the river, Bostrichia scorpioides and Delesseria Leprieurii Mont., two species of Algæ which I have found in all our estuaries from the Hudson to Tampa Bay. In company with them in the Ashley River, I found—

Achnanthes brevipes, Ag.
Bacillaria paradoxa, Ehr.
Meloseira nummuloides, Kg.

In fresh water ditches, at the same place, I found the following Algæ, viz:

Vaucheria cespitosa, Ag.
Spirogyra decimina, Kg.

with the following Diatomaceæ, viz:

Bacillaria paradoxa, Ehr.
Diatoma Ehrenbergii, Kg.
Himantidium arçus, Ehr.
Pinnularia viridis, Ehr.
Surirella splendida, Ehr.

MIDDLETON PLACE, ASHLEY RIVER.

Dec. 16*th*, 1849.—In an artificial pond or reservoir at this locality, I found a great variety of interesting objects, among which were the following—

Desmidieæ.
Ankistrodesmus falcatus, Corda.
Arthrodesmus convergens, Ehr.
" incus, Bréb.
Cosmarium margariferum, Menegh.
Docidium verrucosum, B.
Euastrum elegans, Bréb.
Pediastrum ellipticum, Hass.
" heptactis, Menegh.
" Napoleonis, Menegh.
Scenedesmus quadricauda, Bréb.
Sphaerozosma excavatum, Ralfs.
* " serratum, B.

Desmidieæ.
Staurastrum gracile, Ralfs.
" muticum, Bréb.
Xanthidium cristatum, Bréb.

Infusoria.
Arcella vulgaris, Ehr.
" dentata, Ehr.
Lepadella ovalis, Ehr.
Monostyla lunaris, Ehr.
Peridinium cinctum, Ehr.
Rotifer vulgaris, Schrank.
Squamella oblonga, Ehr.

SAVANNAH, GA.

December, 1849.—I had long entertained the belief that the earth of rice fields, from its frequent submergence, must contain a considerable quantity of infusorial remains; and on visiting Savannah, I gladly availed myself of the opportunity to determine the truth of this supposition. The amount of infusorial remains which I detected far exceeded my expectations, but to my surprise I found that a large portion of the remains were of forms which only inhabit salt or brackish waters. Many of these forms are large enough to be seen by means of a pocket Coddington lens, and indeed it was thus that I first detected the infusorial character of the earths referred to. The large triangular Triceratium favus, Ehr., and the circular discs of Coscinodiscus subtilis, Ehr., may thus be seen in considerable numbers on the surface of every fresh fracture of the earth thrown from the rice-field ditches.

It is not merely the superficial layers which contain these remains, but earth thrown out from the depth of fifteen to twenty feet, as at the excavations for foundations and ditches at Fort Pulaski and Fort Johnson, abound in the same fossils, among which, besides Spongiolites and Phytolitharia, the following Diatomaceæ were noticed:

Actinocyclus, several species.
Actinoptychus senarius, Ehr.
" denarius, Ehr.
Coscinodiscus radiatus, Ehr.
" subtilis, Ehr.
Cocconema cymbiforme, Ehr.
*Eupodiscus radiatus, B.
Gallionella sulcata, Ehr.
" varians, Ehr.
Pinnularia placentula, Kg.
" elliptica, Kg.
Rhaphoneis rhombus, Ehr.
Surirella splendida, Ehr.
Triceratium favus, Ehr.
" alternans, B.
Terpsinoë musica, Ehr.
Zygoceros rhombus, Ehr.

It will be noticed that all these forms are such as are now common in estuaries along the Atlantic coast.

In a fresh water ditch, about a mile below the city of Savannah, and communicating directly with the river, I found the following Diatomaceæ in a living state.

Bacillaria paradoxa, Ehr.
Coscinodiscus subtilis, Ehr.
Meloseira arenaria, Moore.
Pinnularia viridis, Ehr.
*Odontella Mobilensis, B., with spicules of sponge

In another fresh water ditch, in the same vicinity, I noticed among Draparnaldia glomerata, Ag., and Spirogyra quinina, Kg., the following forms, viz:

Closterium lunula, Ehr.
Coscinodiscus excentricus, Ehr., dead.
Navicula hippocampus, Ehr.
Naunema, undetermined, with long slender frustules.
Synedra vitrea, Ehr.
Surirella splendida, Ehr.

SWAMP ON THE ROAD TO BONAVENTURE, NEAR SAVANNAH.

On the 24th of December, I collected Hydrocharis spongiosa, or "Coltsfoot," from a small swamp near the roadside, about a mile from Savannah; and on examining it with a microscope, I found that the small hairs which cover its aquatic roots give an admirable display of the phenomena of the circulation of the sap. These hairs are as transparent as glass, and in each one a turbid fluid may be seen in rapid motion, along the walls of the cells. Slowly revolving c t oblasts were also noticed in some of the hairs. Entangled among the roots of this plant I noticed specimens of Hydatina senta, Ehr., and frustules of Eunotia diodon, Ehr.

Near the same locality I found Botrydium argillaceum, Wall? and Vaucheria racemosa, Lyngb.

POND BY THE SIDE OF THE RAIL-ROAD, NEAR SAVANNAH.

Dec. 27th, 1850.—The bottom of this pond was covered with beautiful, waving, plume-like masses of Myriophyllum, among the leaves of which the following species were found :—

ALGÆ.

Bulbochæte setigera, Ag.
Tolypothrix distorta, Kg.

—

DESMIDIEÆ.

Ankistrodesmus falcatus, Corda.
Aptogonum Baileyi, Ralfs.
Closterium setaceum, Ehr.
Cosmarium Broomeii, Thwaites.
" cucumis, Corda.
" pyramidatum, Bréb.
Desmidium Swartzii, Ag.
Didymoprium Grevillii, Ralfs.
Docidium baculum, Bréb.
" verrucosum, B.
" constrictum, B.
Euastrum crassum, Bréb.

DESMIDIEÆ.

Euastrum didelta, Ralfs.
" elegans, Bréb.
" muricatum, B.
" rostratum, Ralfs.
Micrasterias Americana, Ralfs.
" rotata, Ralfs.
Penium digitus, Bréb.
*Triploceras verticillatum, B.
* " gracile, B.
Sphærozosma excavatum, Ralfs.
* " serratum, B.
Xanthidium cristatum, Ehr.

—

INFUSORIA.

Arcella vulgaris, Ehr.
Peridinium cinctum, Ehr.

DITCHES NEAR THE CANAL OF SAVANNAH.

On the road to the steam saw-mill, above Savannah and near the canal, the following species were seen in ditches, viz:

ALGÆ.

Chætophora pisiformis, Ag.
Nostoc, sp. undetermined.
Spirillum, sp. do. moving actively.
Spirogyra decimina, Kg.

—

DESMIDIEÆ.

Closterium acerosum, Schrank.

—

DIATOMACEÆ.

Bacillaria paradoxa, Ehr., abundant and active.
Gallionella aurichalcea, Ehr.

DIATOMACEÆ.

Naunema, sp. undetermined, with long slender frustules.
" " " with lanceolate frustules.
Navicula amphirhynchus, Ehr.
Synedra vitrea, Kg.

—

INFUSORIA.

Arcella vulgaris, Ehr.
Euglena viridis, Ehr.
Rotifer vulgaris, Schrank.
Synura uvella, Ehr.

VICINITY OF GRAHAMVILLE, BEAUFORT DISTRICT, S. C.

January, 1850.—In the ditches and "Backwater" of Dr. Bolen's rice field, near Grahamville, S. C., I detected the following species on the 1st of January, 1850.

Desmidieæ.

Ankistrodesmus falcatus, Corda.
Aptogonum Baileyi, Ralfs.
Arthrodesmus convergens, Ehr.
Closterium acerosum, Schrank.
" setaceum, Ehr.
Cosmarium ovale, Ralfs.
Desmidium Swartzii, Ag.
Didymocladon furcigerus, Ralfs.
Didymoprium Borreri, Ralfs.
Docidium clavatum, Bréb.
" minutum, Ralfs.
" nodulosum, Bréb.
Hyalotheca dissiliens, Bréb.
Micrasterias furcata, Ag.
" Baileyi, Ralfs.

Desmidieæ.

Micrasterias fimbriata, Ralfs.
" Americana, Ralfs.
*Sphærozosma serratum, B.
Staurastrum margaritaceum, Ehr.

—

Infusoria.

Actinophrys viridis, Ehr.
Arcella vulgaris, Ehr.
Megalotrocha alboflavicans, Ehr.
Ophrydium versatile, Ehr.
*Peridinium Carolinianum, B.
Rotifer vulgaris, Schr.
Stentor polymorphus, Ehr.
Vorticella chlorostigma, Ehr.

—

Hydra viridis.

This locality is chiefly remarkable for the great abundance of the curious and novel form Peridinium Carolinianum. See p. 41.

GRAHAMVILLE, S. C.—*continued.*

In a small ditch by the side of the road leading from Grahamville to Savannah, and about a mile from Grahamville, the following forms were seen, viz:

Desmidieæ.

Cosmarium margaritiferum, Menegh., abundant.
Euastrum crassum, Bréb.
" insigne, Hass.
Micrasterias crenata, Bréb.
" denticulata, Bréb., abundant.

Desmidieæ.

Tetmemorus Brebissonii, Ralfs., abundant.
" granulatus, Ralfs.

—

Diatomaceæ.

Eunotia tetraodon, Ehr.

GRAHAMVILLE, S. C.—*continued.*

In pools near the dam of a "Backwater," on the road to Savannah, about two and a half miles from Grahamville, great numbers of the following species were found, viz:

Desmidieæ.

Closterium lunula, Ehr.
Desmidium Swartzii, Ag.
Didymoprium Borreri, Ralfs.
Docidium Ehrenbergii, Ralfs.
" minutum, Ralfs.
" nodulosum, Bréb.
Euastrum ansatum, Ehr.
" affine, Ralfs.
" didelta, Ralfs.
Micrasterias crenata, Bréb.

Desmidieæ.

Micrasterias denticulata, Bréb.
Penium closteroides, Ralfs.
(in immense numbers.)
Spirotænia condensata, Bréb.

—

Infusoria.

Arcella vulgaris, Ehr.
" hyalina, Ehr.
Difflugia proteæformis.
* " spiralis, B.

GRAHAMVILLE, S. C.—*continued.*

In a ditch by the roadside, near Gopher Hill, I found—

Micrasterias pinnatifida, Ralfs.
Xanthidium armatum, Ralfs.
Pinnularia amphigompha, Ehr.
" iridis, Ehr.

GRAHAMVILLE, S. C.—*continued.*

Near the village, by the side of the road to "Hap Hazard," I found among the roots of Utricularia verticillata, the following species, viz:

DESMIDIEÆ.
Aptogonum desmidium, Ehr.
Closterium acerosum, Schr.
Desmidium Swartzii, Ag.
Didymoprium Grevillii, Ralfs.
Euastrum affine, Ralfs.
Penium interruptum, Bréb.
Spirotænia condensata, Bréb.
Xanthidium cristatum, Bréb.
" fasciculatum, Ehr.

DIATOMACEÆ.
Himantidium bidens, Ehr.
Diatoma stellata, B.

INFUSORIA.
Amœba princeps, Ehr.
Arcella vulgaris, Ehr.
" hyalina, Ehr.
Dinobryon sertularia, Ehr.
Hydatina senta, Ehr.
*Peridinium carolinianum, B.
Pterodina patina, Ehr.

GRAHAMVILLE, S. C.—*continued.*

A ditch by an old saw-mill near the village furnished these species, viz:

DESMIDIEÆ.
Euastrum ansatum, Ehr., abundant.
Hyalotheca dissiliens, Bréb.
Micrasterias rotata, Ralfs.
Penium closteroides, Ralfs.
" interruptum, Bréb.
Spirotænia condensata, Bréb.

DIATOMACEÆ.
Naunema, undetermined.
Surirella splendida, Ehr.

ALGÆ.
Tetraspora lubrica, Ag.
Vaucheria cespitosa, Ag., with a parasitic Rotifer in its branches.

GRAHAMVILLE, S. C.—*continued.*

The mill-pond at "Hap Hazard" furnished the following species, viz:

DESMIDIEÆ.
Closterium acerosum, Schr.
" lunula, Ehr.
Didymoprium Borreri, Ralfs.
Docidium nodulosum, Bréb.
Euastrum verrucosum, B.
Micrasterias incisa, Kg.
Micrasterias denticulata, Bréb.
Penium digitus, Bréb.
Scenedesmus obliquus, Kg.
*Sphærozosma serratum, B.
Spirotænia condensata, Bréb.
Staurastrum margaritaceum, Ehr.

2

INFUSORIA.

Amœba princeps, Ehr.
Arcella vulgaris, Ehr.
" dentata, Ehr.
Epistylis anastatica, Ehr.
Hydatina senta, Ehr.
Rotifer vulgaris, Schr.
Scaridium longicaudum, Ehr.
Stentor polymorpha, Ehr.

HAZARD'S BACK CREEK, NEAR GRAHAMVILLE, S. C.

In the floating scum of this salt water creek, at Mr. Bolen's Landing, the following Diatomaceæ were detected :—

Amphiprora alata, Ehr.
Amphora libyca, Ehr.
Bacillaria paradoxa, Ehr.
Coscinodiscus subtilis, Ehr.
Navicula Baltica, Ehr.
Pinnularia interrupta, Ehr.

The following Algæ were also found at the same place, viz :

Delesseria Leprieurii, Mont.
Ectocarpus littoralis, Lyngb.

BRYAN COUNTY, GA.

January and February, 1850.—In ditches by the side of the Ogeechee Causeway, on the road from Savannah to Darien, I noticed the following species among the roots of Utricularia verticillata, which grows here in great profusion.

DESMIDIEÆ.

Ankistrodesmus falcatus, Corda.
Arthrodesmus convergens, Ehr.
Closterium acerosum, Schr.
" Ehrenbergii, Menegh.
" Leiblenii, Kg.
" setaceum, Ehr.
Didymoprium Borreri, Ralfs.
Docidium Ehrenbergii, Ralfs.
" nodulosum, Bréb.
Euastrum rostratum, Ralfs.
Micrasterias americana, Ralfs.
" denticulata, Bréb.
" incisa, Kg.
" rotata, Ralfs.

DIATOMACEÆ.

Himantidium arcus, Ehr.
Tabellaria flocculosa, Ehr.

INFUSORIA.

Arcella dentata, Ehr.
" vulgaris, Ehr.
Euglena pleuronectes, Ehr.
Euplotes charon, Ehr.
Rotifer vulgaris, Schr.
" macrurus, Ehr.
Stentor polymorpha, Ehr.
Synura uvella, Ehr.

ALGÆ.

*Aporea ambigua, B. (Pl. 3, fig. 3.)
Bulbochæte setigera, Ag.
Coleochæte scutata, Bréb.

At the same locality, Hydrocharis spongiosa, Riccia fluitans, and a species of Azolla, occur abundantly.

BRYAN CO., GA.—*continued.*

RICE FIELD MUDS.

The mud from the rice fields on the Ogeechee was collected at the embankments by the side of the canals and ditches on the following estates, viz:

Cherry Hill, belonging to R. J. Arnold, Esq.
Strother Hall, " Col. McAllister.
A new plantation, " Judge Langdon Cheves.

These muds all agreed in character with those examined near Savannah, and furnished the following species, viz:

Actinoptychus denarius, Ehr.
" senarius, Ehr.
Coscinodiscus excentricus, Ehr.
" subtilis, Ehr.
Dictyocha fibula, Ehr.
Gallionella sulcata, Ehr.
Pinnularia interrupta, Kg.
" viridis, Ehr.
Rhaphoneis rhombus, Ehr.
Surirella splendida, Ehr.
Terpsinoë musica, Ehr.
Triceratium favus, Ehr.
" alternans, B.
" reticulum, Ehr.
Zygoceros rhombus, Ehr.

—

Pollen pini.
Phytolitharia, &c.

BRYAN CO., GA.—*continued.*

WHITE HALL, THE RESIDENCE OF R. J. ARNOLD, ESQ.

In a ditch of an old rice field, and at some distance from the river, the following species were found among the leaves of Utricularia verticillata, viz:

Bacillaria paradoxa, Ehr.
Gallionella aurichalcea, Ehr.
Himantidium arcus, Ehr.
Synedra spectabilis, Ehr.
" vitrea, Ehr.
Closterium acerosum, Schr.

—

Arcella dentata, Ehr.
Vaginicola crystallina, Ehr.

DITCH NEAR THE CHURCH IN THE VICINITY OF WHITE HALL.

This furnished the following:

Desmidieæ.

Ankistrodesmus falcatus, Corda.
Aptogonum desmidium, Ehr.
Arthrodesmus convergens, Ehr.
" incus, Bréb.
Didymoprium Borreri, Ralfs.
Docidium verrucosum, B.
Euastrum affine, Ralfs.
Micrasterias crenata, Bréb.
Pediastrum heptactis, Menegh.
Penium digitus, Bréb.
Scenedesmus obliquus, Kg.
Staurastrum dejectum, Bréb.
" gracile, Ralfs.
Xanthidium aculeatum, Ehr.

DIATOMACEÆ.
Pinnularia amphigompha, Ehr.
Diatoma stellaris, B.

INFUSORIA.
Dinobryon sertularia, Ehr.
Euglena longicauda, Ehr.
Peridinium cinctum, Ehr.
Rotifer vulgaris, Schr.
Stentor polymorpha, Ehr.

GLYNN COUNTY, GA.

HOPETON, ON THE ALTAMAHA, RESIDENCE OF J. HAMILTON COUPER, ESQ.

About the time when I arrived at Mr. Couper's hospitable mansion, there had been several severe frosts, and some days of cold rains. Under these circumstances, the opportunities to collect the microscopic forms were much less favorable than at the preceding localities. The rice-field muds at this locality proved to be quite rich in remains of diatomaceous shells, agreeing with those noticed on the Savannah and Ogeechee, and furnishing abundance of the following forms, viz :

Antinocyclus, several species.
Actinoptychus denarius, Ehr.
" senarius, Ehr.
*Campylodiscus argus, B.
Eupodiscus Rogersii, Ehr.
* " radiatus, B.
Gallionella sulcata, Ehr.
Pinnularia amphyoxys, Ehr.
Pinnularia interrupta, Kg.
" viridis, Ehr.
Rhaphoneis rhombus, Ehr.
Terpsinoë musica, Ehr.
Triceratium favus, Ehr.
" reticulum, Ehr.
Zygoceros rhombus, Ehr.

In a rice-field ditch, remote from the river, I found the following species in a living state, viz:

DESMIDIEÆ.
Closterium lanceolatum, Kg.
Desmidium Swartzii, Ag.
Micrasterias crenata, Bréb.
Scenedesmus obliquus, Kg.

—

DIATOMACEÆ.
Cocconema cymbiforme, Ehr.
Eunotia gibba, Ehr.
" librile, Ehr.
" amphyoxys, Ehr.
Fragillaria pectinalis, Ehr., in large masses.
Gallionella aurichalcea, Ehr.
Gomphonema constrictum, Ehr.
Navicula hippocampus, Ehr.
Naunema, undet., frustules slender.

DIATOMACEÆ.
Surirella splendida, Ehr.
Synedra vitrea, Kg.

—

INFUSORIA.
Gonium pectorale, Ehr.
Hydatina senta, Ehr.
Lacinularia socialis, Ehr.
Synura uvella, Ehr.
Vaginicola crystallina, Ehr.

—

ALGÆ, &c.
*Aporea ambigua, B.
Coleochæte scutata, Bréb.
Mougeotia genuflexa, Ag.

HOPETON.—*continued.*

In a ditch leading from a small artesian well in the rice fields at Hopeton, the following forms were noticed, viz:

Closterium lunula, Ehr.
" lanceolatum, Kg.
Eunotia gibba, Ehr.
Surirella splendida, Ehr.
Synedra vitrea, Kg.
Arcella dentata, Ehr.
Euglena viridis, Ehr.
Rotifer vulgaris, Schr.

In a ditch behind the Negro Hospital at Hopeton, I found the following, viz:

Closterium Dianæ, Ehr.
" moniliferum, Ehr.
Docidium clavatum, Kg.
Himantidium arcus, Ehr.
Synedra vitrea, Kg.
Dinobryon vulgaris, Ehr.
Peridinium cinctum, Ehr.
Rotifer vulgaris, Schr.
and several species of Cyclops, Daphnia and Gammarus.

GLYNN CO., GA.—*continued.*

ST. SIMON'S ISLAND.

In the salt marsh mud from the "Cut-off" at the north end of St. Simon's Island, the following species were found, either alive or evidently in a very recent condition, viz:

*Campylodiscus argus, B.
Coscinodiscus oculis iridis, Ehr.
" radiatus, Ehr.
" subtilis, Ehr.
*Eupodiscus radiatus, B.
Gallionella sulcata, Ehr.
Rhaphoneis rhombus, Ehr.
Terpsinoë musica, Ehr.
Triceratium favus, Ehr.
Zygoceros rhombus, Ehr.

The same forms were noticed in mud from the "Inland Passage" from Darien to Jacksonville, Fa. The resemblance of these marsh muds to those thrown out in digging the canals of the rice fields, and the identity of the forms contained in them, serve to show that the rice fields were once salt marshes, and have been cut off from the influence of the ocean either by elevations of the coast, or changes in the course of the rivers. It should be borne in mind, however, that marine forms occur in estuaries far above where the surface water is brackish.

FLORIDA.

PILATKA.

Feb. 20*th*, 1850.—In sphagnous swamps, near the village of Pilatka, Florida, I found the species named below.

DESMIDIEÆ.
Closterium acerosum, Schr.
" Dianæ, Ehr.
*Cosmarium depressa, B.
Didymoprium Borreri, Ralfs.
Didymocladon furcigerus, Ralfs.
Docidium minutum, Ralfs.
Euastrum elegans, Bréb.
" sublobatum, Bréb.
Micrasterias truncata, Bréb.
Penium digitus, Bréb.
Staurastrum gracile, Ralfs.
" tricorne, Bréb.
" polymorphum, Bréb.
Xanthidium armatum, Ehr.
" fasciculatum, Ehr.

DIATOMACEÆ.
Himantidium diodon, Ehr.
Pinnularia viridis, Ehr.

—

INFUSORIA.
Actinophrys viridis, Ehr.
Amœba princeps, Ehr.
Arcella dentata, Ehr.
" vulgaris, Ehr.
Metopidia lepadella, Ehr.
Monostyla lunaris, Ehr.
Noteus quadricornis, Ehr.
Pterodina patina, Ehr.
Rotifer vulgaris, Schr.
Stylonychia mytilus, Ehr.
Cothurnia imberbis, Ehr.

PILATKA.—*continued.*

The following species were found in a living state, attached to a log in the St. John's River, at Pilatka, viz :

Bacillaria paradoxa, Ehr.
*Campylodiscus argus, B.
Odontella polymorpha, Kg.

PILATKA.—*continued.*

In a ditch by the roadside, three miles from Pilatka, I found these species, viz :

DESMIDIEÆ.
Didymoprium Borreri, Ralfs.
(in conjugation.)
" Grevillii, Ralfs.
Euastrum ampullaceum, Ralfs.
Hyalotheca dissiliens, Bréb.
Tetmemorus Brebissonii, Ralfs.

DIATOMACEÆ.
Eunotia tetraodon, Ehr.

—

INFUSORIA.
Colurus tricuspidatus, Ehr.
Dinobryon sertularia, Ehr.
Pterodina patina, Ehr.
Stentor polymorphus, Ehr.

PONDS NEAR PILATKA.

In the "First Pond," about five miles west of Pilatka, the following species were collected, viz :

DESMIDIEÆ.
Ankistrodesmus falcatus, Corda.
Cosmarium amœnum, Bréb.
" pyramidatum, Bréb.
Didymoprium Borreri, Ralfs.
Docidium Ehrenbergii, Ralfs.
Euastrum elegans, Bréb.
Micrasterias truncata, Bréb.
Spirotænia condensata, Bréb.
Sphærozosma excavatum, Ralfs.
* " serratum, B.
Staurastrum dejectum, Bréb.
Tetmemorus Brebissonii, Ralfs.

DESMIDIEÆ.
Xanthidium fasciculatum.

—

INFUSORIA.
Arcella angulata, Ehr.
Euglena longicauda, Ehr.
Megalotrocha alboflavicans, Ehr.
Monostyla lunaris, Ehr.
*Peridinium carolinianum, B.

—

ALGÆ.
*Aporea ambigua, B.
Bulbochæte setigera, Ag.

In the "Second Pond," near the above locality, were found—

*Cosmarium depressum, B.
*Didymocladon cerberus, B.
*Micrasterias arcuata, B.
* " expansa, B.
Micrasterias furcata, Ehr.
" radiosa, Ehr.
Penium digitus, Ralfs.
Xanthidium fasciculatum, Ehr.

PILATKA.—*continued.*

In a deep ravine south of Pilatka, I found large brown masses of Diatoma Ehrenbergii, Kg., attached to twigs, etc., in a small stream.

SHELL BANKS OF PILATKA.

While at Pilatka, I carefully examined the immense deposit of fluviatile shells upon which the town is built, and which is chiefly made up of Paludina vivipara, Ampullaria depressa, several small Helices, Melaniæ, etc., with valves of an undetermined Unio. I could detect no trace of microscopical organisms in any of the earthy matter accompanying them.

PILES' "NEW PLACE," FA.

At "Piles'," about forty miles west of Pilatka, on the road to Tampa, I examined the rock recently excavated in forming a well. It proved to be the White Orbitulite limestone, containing large masses of flint. Both the limestone and flint abound in microscopical Polythalamia, which may be detected in the flint by mounting thin fragments in Canada balsam. Rock of similar character was seen at numerous places between Pilatka and Tampa, and it even forms extensive ridges, of the height of three or four hundred feet, giving an appearance to the interior of Florida very different from the flat monotonous aspect which it is generally supposed to present.

OCALA, FA.

Feb. 26*th*, 1850.—In a "Lime-sink" near Ocala, on the road to Tampa, I found the following forms among the roots of Lemna minor, which covered the surface of the water, viz:

Docidium nodulosum, Bréb.
Cosmarium Thwaitesii, Ralfs.
" margaritaceum, Menegh.
—
Arcella vulgaris, Ehr.
Euglena pleuronectes, Ehr.
Rotifer vulgaris, Schr.

Salpina mucronata, Ehr.
—
*Aporea ambigua, B.
Coleochæte scutata, Bréb.
Tyndaridea cruciata, Harv.
Spirogyra quinina, Kg.

DADE'S BATTLE GROUND, FA.

At the pond near Dade's Battle Ground, I found the following forms, viz:

Desmidieæ.
Arthrodesmus convergens, Ehr.
" incus, Bréb.
*Cosmarium depressum, B.
" connatum, Bréb.
" margaritiferum, Menegh.
" ornatum, Ralfs.
Docidium minutum, Ralfs.
Euastrum binale, Ralfs.
" elegans, Bréb.
Micrasterias crenata, Bréb.
" incisa, Kg.
" pinnatifida, Kg.
" radiosa, Ag.

Desmidieæ.
*Micrasterias ringens, B.
Pediastrum Boryanum, Menegh.
" heptactis, Menegh.
*Sphærozosma serratum, B.
Xanthidium cristatum, Bréb.
—
Infusoria.
Arcella dentata, Ehr.
*Difflugia spiralis, B.
Gonium glaucum, Ehr.
Rotifer vulgaris, Schr.
Salpina mucronata, Ehr.

DITCH BY ROADSIDE, THIRTY MILES EAST OF TAMPA.

At this locality I collected the following:

Cosmarium pyramidatum, Bréb.
Docidium minutum, Ralfs.
Euastrum sublobatum, Bréb.
Micrasterias pinnatifida, Kg.
" truncata, Bréb.
Penium digitus, Bréb.
Pterodina patina, Ehr.
Rotifer vulgaris, Schr.
Stentor polymorpha, Ehr.

"WARM SPRING" ON THE ROAD TO TAMPA.

This spring furnished the following species, viz:

Closterium Ehrenbergii, Menegh.
" turgidum, Ehr.
Docidium nodulosum, Bréb.
Cocconema cymbiforme, Ehr.
Eunotia gibba, Ehr.
" librile, Ehr.
Gallionella aurichalcea, Ehr.
Himantidium arcus, Ehr.

The surface of the spring was covered with a green mucous mass, composed of Nostoc-like filaments, mingled with Mougeotia genuflexa, Ag., and Spirogyra decimina, Kg.

LITTLE HILLSBOROUGH RIVER, ON THE ROAD FROM PILATKA TO TAMPA.

This river furnished the following, viz:

Desmidieæ.
Closterium Dianæ, Ehr.
" Ehrenbergii, Menegh.

Diatomaceæ, &c.
Cocconeis pediculus, Ehr.
Cocconema cymbiforme, Ehr.
*Peridinium carolinianum, B.
Pinnularia viridis, Ehr.
Synedra vitrea, Kg.

WITHLACOOCHEE RIVER, ON THE ROAD TO TAMPA.

March 1st, 1850.—In this river I found, among the roots of Pistia stratiotes, the following species, viz:

Desmidieæ.
Closterium Dianæ, Ehr.
" Ehrenbergii, Menegh.
" setaceum, Ehr.
Micrasterias americana, Ralfs.

—

Diatomaceæ, &c.
*Amphiprora ornata, B. Pl. 2, figs. 15 and 23.
Cocconeis pediculus, Ehr.
Cocconema cymbiforme, Ehr.
Eunotia gibba, Ehr.
" librile, Ehr.
Fragillaria pectinalis, Ehr.
Himantidium arcus, Ehr.
Surirella splendida, Ehr.
Synedra vitrea, Kg.

BIG HILLSBOROUGH RIVER, ON THE ROAD FROM PILATKA TO TAMPA.

In this river I noticed the following species in a living state:

Cocconema cymbiforme, Ehr.	Arcella dentata, Ehr.
Eunotia gibba, Ehr.	" vulgaris, Ehr.
Surirella splendida, Ehr.	—
Synedra vitrea, Kg.	Batrachospermum moniliforme, Roth.
Terpsinoë musica, Ehr.	Spirogyra decimina, Kg.

It was at this locality that I first saw living chains of that exquisite form, the Terpsinoë musica, Ehr. The frustules contained yellowish endochrome and granules, irregularly scattered.

VICINITY OF TAMPA, (FORT BROOKE), FA.

The mud of a salt-marsh, half a mile east of Fort Brooke, furnished the following Diatomaceæ, viz:

Amphiprora constricta, Ehr.	Navicula baltica, Ehr.
Coscinodiscus subtilis, Ehr.	Stauroptera aspera, Ehr.
*Eupodiscus radiatus, B.	Triceratium favus, Ehr.
Gallionella sulcata, Ehr.	" reticulum, Ehr.

TAMPA.—*continued.*

On the shores of Hillsborough River, near the Hotel at Tampa, I noticed that the sand below high-water mark was of the peculiar yellowish or ferruginous tint which often indicates the presence of living Diatomaceæ. Microscopical observations proved the presence of large numbers of a species of Amphiprora, (see figs. 2, 3, 4, Pl. 2,) whose living frustules showed four parallel yellowish bands, and which I shall refer to as Amphiprora fasciata, B. A small sigmoid Navicula, probably N. sigma, Ehr., accompanied the Amphiprora.

About a mile and a half above the Hotel, I collected some salt-marsh grasses, attached to which were great quantities of Delesseria Leprieurii, Mont., and Bostrichia scorpioides? and among these Algæ I detected the following:

Diatomaceæ.	Infusoria.
Achnanthes brevipes, Ag.	Carchesium polypinum, Ehr.
Bacillaria paradoxa, Ehr.	Cothurnia maritima, Ehr.
Cerataulus turgidus, Ehr.	" havniensis, Ehr.
Meloseira salina, Kg.	
Stauroptera aspera, Ehr.	Figures of these species of Cothurnia are given on Pl. 3, figs. 11 & 12.
Triceratium favus, Ehr.	

TAMPA.—*continued.*

On the beach in front of the flagstaff at Fort Brooke, I collected the following:

Algæ.
Sargassum vulgare, Ag.
Spyridia filamentosa, Harv.
Ceramium clavulatum, Ag.

Diatomaceæ.
*Achnanthes ? arenicola, B, see page 38.
Bacillaria paradoxa, Ehr.
*Grammatophora stricta, Ehr.
Gallionella sulcata, Ehr.
Rhabdonema adriaticum, Kg.

On the west side of the bay, the following Algæ were found on the beach at low tide, viz:

Bangia fusco-purpurea, Lyngb.
Calothrix confervicola, Ag.
Ceramium clavulatum, Ag.
Gracilaria multipartita, J. Ag.
Polysiphonia Olneyi ? Harv.

INFUSORIAL STRATUM NEAR TAMPA.

Between the ferry at Tampa and the well known locality of silicified corals at Ballast Point, on Hillsborough Bay, and directly on the shore of the bay, I detected a highly interesting stratum of fossil marine Diatomaceæ or Infusoria. It is exposed for at least a quarter of a mile along the shore, and from five to ten feet of its thickness may be seen. In its external characters, (whiteness, lightness, fissility, &c.,) it has some resemblance to the infusorial strata of Virginia, but is much more indurated, so that, although it is easy to show that it is made up of the remains of Diatomaceæ, spicules of sponges, &c., it is yet difficult to isolate and determine the individual species. The following forms, how ever, were distinctly recognized, viz:

Actinoptychus senarius, Ehr.
Coscinodisci, undetermined fragments.
Denticella ? tridentata, Ehr.=Zygoceros Tuomeyi, B.
Gallionella sulcata, Ehr.
Rhaphoneis rhombus, Ehr.

with numerous sponge spicules.

This infusorial earth, like that at Petersburg, Va., changes in a singular manner, to a salmon color, when exposed to the *vapor* of Turpentine or Canada Balsam. The geological position is probably in the upper part of the Eocene Tertiary, for a bed of shells, which apparently belong to that epoch, lies a short distance to the east of the infusorial bed.

This discovery of a marine infusorial stratum, similar to those of Virginia and Maryland, but at so great a distance from them, is, I think, of much interest, and gives reason to hope for the detection of similar deposits at many intermediate points.

Some interesting remarks on the geology of the localities in the vicinity of Tampa and Ballast Point, by J. H. Allen, may be found in *Silliman's Journal*, New Series, Vol. I., p. 38, and others by T. A. Conrad, in the same series, Vol. II., pp. 36, 399.

ST. AUGUSTINE, FA.

March 16*th*, 1850.—The mud of the St. Sebastian River, collected at the bridge west of St. Augustine, proved to be very rich in siliceous shells of recent and living Diatomaceæ, among which the following were noticed, viz:

Actinoptychus senarius, Ehr.
Actinocyclus, several species.
Biddulphia pulchella, Gray.
Coscinodiscus excentricus, Ehr.
" lineatus, Ehr.
" oculus-iridis, Ehr.
" subtilis, Ehr.
Dityocha fibula, Ehr
*Eupodiscus radiatus, B.
" Rogersii, Ehr.
Gallionella sulcata, Ehr.
Meloseira salina, Kg.
†Navicula elongata.
" baltica, Ehr.
*Pinnularia Couperi, B.
" lyra, Ehr.
*Pyxidicula compressa, B.
Rhaphoneis rhombus, Ehr.
Stauroptera aspera, Ehr.
*Surirella circumsuta, B.
" splendida, Ehr.
Triceratium favus, Ehr.
" hexagonalis, B.
Zygoceros rhombus, Ehr.

The following Algæ were found at the same place, viz:

Bostrichia scorpioides ? Mont.
Delesseria hypoglossum, Lamour.
" Leprieurii, Mont.
Porphyra vulgaris, Ag.
Ulva latissima, L.

ST. AUGUSTINE.—*continued.*

In the mud at the foot of the sea wall, near the old Spanish Fort St. Marco, I noticed the following Diatomaceæ, viz:

Ceratoneis closterium, Ehr. very active.
Coscinodiscus lineatus, Ehr.
" radiatus, Ehr.
" subtilis, Ehr.
Grammatophora marina, Ehr.
Navicula baltica, Ehr.
" sigma, Ehr.

The following Algæ were also noticed at the same locality, viz:

Bostrichia scorpioides ? Mont.
Callithamnion, undetermined.
Ectocarpus siliculosus, Lyngb.
Gelidium corneum, Lamour.
Gracilaria multipartita, Clem.
Rhabdonia Baileyi, Harv.
Spyridia filamentosa, Wulf.

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† Specimens which I received from London, agreeing well with our own, were marked *N. elongata*, but by whom they were so named I do not know. I had been in the habit of calling it *N. diagonalis*, but had not published any notice of it. Its delicate diagonal, transverse, and longitudinal rows of dots make it an interesting microscopic object.

In a grayish slime covering the creek west of St. Augustine I found

Amphiprora alata, Ehr. See figs. 8, 9, 10, Pl. 2.
Amphora libyca, Ehr.
Pinnularia interrupta, Ehr.
Rhaphoneis rhombus, Ehr.

In a fresh-water pond, on St. Anastasia Island, near St. Augustine, I found on the 26th March, 1850, the following, viz:

Algæ.
*Aporea ambigua, B.
Chætophora pisiformis, Ag.
Coleochæte scutata, Bréb.
In fruit, abundant on petioles of Sagittaria.

Diatomaceæ.
Himantidium arcus, Ehr.
Cocconeis pediculus, Ehr.
Pinnularia viridis, Ehr.

Arcella vulgaris, Ehr.
*Pterodina magna, B.
Rotifer vulgaris, Schr.
Stentor polymorphus, Ehr.

ST. ANASTASIA ISLAND.—*continued.*

On the "Coquina" Rocks, near the light-house, on Anastasia Island, I found the following forms, viz:

Algæ.
Ceramium rubrum, Ag.
Gelidium corneum, Huds.
Laurencia dasyphylla, Woodw.
Rhabdonia Baileyi, Harv.

Diatomaceæ.
Achnanthes minutissima, Kg.
Rhipidophora crystallina, Kg.
Schizonema quadripunctata, Ag.

Acineta Lyngbyi ? Ehr. See fig. 16, Pl. 3.

On the sands of the above locality I noticed yellowish spots, which owed their color to great numbers of Amphiprora quadrifasciata, B., and a species of Amphora, apparently new, which moved very rapidly. I have named it Amphora amphioxys, B. See page 38.

ST. AUGUSTINE.—*continued.*

In fresh-water ditches in the pine barrens near St. Augustine, I observed these forms, viz:

Closterium acerosum, Schr.
"   Dianæ, Ehr.
"   turgidum, Ehr.
Euastrum oblongum, Ralfs.
Staurastrum dilatatum, Ehr.
Eunotia diodon, Ehr.

Brachionus urceolaris. See fig. 17.

—

Bulbochæte setigera, Ag.
Mougeotia genuflexa, Ag.
Tyndaridea cruciata, Harv., in fruit.

VOLUSIA, ON THE ST. JOHN'S RIVER, FA.

On the roots of the "Water Lettuce," Pistia stratiotes, L.,† I collected at Volusia, on the 9th of April, 1850, the following species, viz:

DIATOMACEÆ.

Achnanthes, undetermined. See fig. 11, Pl. 2.
Amphora libyca, Ehr. Fig. 12, Pl. 12.
Bacillaria paradoxa, Ehr. Abundant, and very active.
Cocconeis pediculus, Ehr.
Cocconema cymbiforme, Ehr.
Eunotia gibba, Ehr.
" nodosa, Ehr.
" librile, Ehr.
Gallionella aurichalcea, Ehr.
" varians, Ehr.
Himantidium arcus, Ehr.
Navicula elongata, Harrison ?
Odontella polymorpha, Kg.
Synedra vitrea, Kg.
Terpsinoë musica, Ehr. Living, and forming zigzag chains.

—

INFUSORIA.

Amœba princeps, Ehr.
Arcella vulgaris, Ehr.
Rotifer vulgaris, Schr.

—

DESMIDIEÆ.

Staurastrum enorme, Ralfs.

ENTERPRISE, FA.

Latitude between 28° and 29° N.

April 10th to 23d, 1850.—On Lake Monroe, 200 miles from the mouth of the St. John's River. This was the most southern point which I visited, and there is no place which I have ever seen which afforded so many delights to the microscopist. The sub-tropical climate produces in the numerous lakes and creeks countless myriads of the most interesting Infusoria and Desmidieæ, which may be collected within a few hundred yards of the boarding-house. The numerous sulphur springs, surrounded by beautiful palmetto groves; the parasitic Tillandsias of several species; the epidendri and parasitic ferns; the lake with its hundreds of alligators, and its strange mixture of marine and fresh-water forms; and lastly, the wonderful shell banks on which Enterprise is built, are all calculated to interest even the most indifferent. I would be glad if every invalid who visits this place could pass as many pleasant hours there as it was my privilege to enjoy.

In Lake Monroe I collected, from among the roots of Pistia stratiotes, the following species, viz:

DESMIDIEÆ.

Closterium Jenneri, Ralfs.
Euastrum ampullaceum, Ralfs.
Pediastrum boryanum, Menegh.

—

ALGÆ.

Coleochæte scutata, Bréb.
Spyrogyra quinina, Kg.

DIATOMACEÆ.

Amphiprora constricta, Ehr. Pl. 2, figs. 5, 6, 7.
* " pulchra, B. Pl. 2, figs. 16 and 18.
Bacillaria paradoxa, Ehr.
Campylodiscus clypeus, Ehr.
* " argus, B. Pl. 2, figs. 24, 25.
Cocconeis pediculus, Ehr.
Cocconema cymbiforme, Ehr.

---

† This gigantic representation of the Lemna of the northern waters grows in vast profusion in the Withlacoochee and St. John's Rivers. Like the Lemna, it contains spiral vessels in its roots, and abounds with Biforines, which actively discharge their raphides in water. See Pl. 3, fig. 1.

ENTERPRISE, FA.—*continued.*

Diatomaceæ.	Infusoria.
Eunotia librile, Ehr.	Arcella vulgaris, Ehr.
Gallionella aurichalcea, Ehr.	Brachionus polyacanthus, Ehr.
Himantidium arcus, Ehr.	Coleps hirtus, Ehr.
Navicula elongata, Har. ?	Cothurnia imberbis, Ehr.
Odontella polymorpha, Kg.	Dinocharis tetractis, Ehr.
Stauroneïs maculata, B.	Floscularia ornata, Ehr.
Surirella ovalis, Bréb.	Opercularia articulata, Goldf.
Synedra vitrea, Kg.	Œcistes crystallinus, Goldf.
" scalaris, Ehr.	Philodina erythropthalma, Goldf.
Terpsinoë musica, Ehr.	Rotifer vulgaris, Schr.
—	Scaridium longicaudum, Ehr.
Infusoria.	Vorticella nebulifera, Bory.
Amœba princeps, Ehr.	

Spongilla fluviatilis, is also abundant in Lake Monroe.

The species of Amphiprora, Bacillaria, Odontella, and Navicula, mentioned in this list, are decidedly marine forms, and have been found by me on the shores of the Atlantic. They also occur in estuaries; but I confess I was surprised to find them so far up the St. John's, and in company with such truly lacustrine forms as many of those above mentioned. To add to the curious mixture of marine and fresh-water species in Lake Monroe, I will mention that the lake abounds with Paludina vivipara, Say, Ampullaria depressa, Say, with Unios, and several other fresh-water molluscs, and yet contains abundance of a living marine zoophyte (Campanularia,) and a large fish of the Ray family, called by the settlers a " Stingaree." A curious living crustacean, a species (probably new) of Sphæroma, also abounds here, and is very destructive to cypress logs, canoes, &c. Many of the silicious forms above mentioned were found in the mud of the creeks leading from the immense sulphur springs near Lake Monroe, and neither the Diatomaceæ, nor the numerous fish which inhabit these waters, appear to dislike the sulphur waters. I daily saw hundreds of large gar-fish which assembled directly over " the boil" of one of these springs, as if it was their favorite resort; and I also noticed that the large Amphiprora pulchra, B., and the Navicula elongata, grew in great profusion in waters charged with sulphuretted hydrogen, as in the outlet of the Green Spring at Mr. Duval's.

SHELL BANKS OF ENTERPRISE, ETC.

The vast deposits of fluviatile shells which exist at Picolata, Volusia, and Enterprise, are of great geological interest. Enterprise and Volusia present bluffs and hills of forty and fifty feet in height, and extending half a mile or more

from the river, which are literally composed of almost nothing else but well preserved shells of the Paludina vivipara, Say, Ampullaria depressa, Say, some undetermined species of Unio, Helix septemvolvis, Melania, and a few others. There is scarcely any mixture of earth, but the shells are clean, and look as if they had been washed ashore after the death of the animals. In some places the beds are sandy, and are hardening into a calcareous sandstone. In one such bed, the superficial stratum furnished a few bones of turtles and undetermined fragments, the bones of some large vertebrate animal. This is, I believe, the same locality where Count Pourtalés collected human bones in a recent sandstone. That the sandstone is *recent* I have no doubt, but the shells from which these banks are formed, though belonging to species now inhabiting the lake and river, were probably accumulated thousands of years ago, under very different circumstances as to elevation, topography, &c., from those now existing. They certainly form the most remarkable fresh-water deposits in the United States. No microscopical forms were detected in these beds, after the most careful search.

PONDS NEAR ENTERPRISE, FA.

April 12th to 18th, 1850.—In fresh-water ponds, near Mr. Duval's boarding house at Enterprise, I found a most abundant supplyof interesting microscopical forms, among which the following were identified:

DESMIDIEÆ.

Ankistrodesmus falcatus, Corda.
Aptogonum Baileyi, Ralfs.
" desmidium, Ehr.
*Cosmarium depressum, B. Pl. 1, fig. 1.
" pyramidatum, Bréb.
Closterium lunula, Ehr.
" setaceum, Ehr.
Didymocladon furcigerus, Ralfs.
* " cerberus, B. Pl. 1, figs. 15, 16.
* " longispinum, B. Pl. 1, fig. 17.
Didymoprium Grevillii, Ralfs.
" Borreri, Ralfs.
*Docidium hirsutum, B. Pl. 1, fig. 8.
" minutum, Ralfs. Pl. 1, fig. 3.
" undulatum, B. Pl. 1, fig. 2.
Euastrum ampullaceum, Ralfs.
" elegans, Bréb.
" insigne, Hass.
" rostratum, Ralfs.
" sublobatum, Bréb.
" verrucosum, Ehr.
Hyalotheca dissiliens, Bréb.
Micrasterias Baileyi, Ralfs.
* " arcuata, B. Pl. 1, fig. 6.
" denticulata, Bréb.
*Micrasterias expansa, B. Pl. 1, fig. 7.
" fimbriata, Ralfs.
" pinnatifida, Kg.
* " quadrata, B. Pl. 1, fig. 5.
" rotata, Ralfs.
" truncata, Bréb. Pl. 1, fig. 20.
Penium Jenneri, Ralfs.
" margaritaceum, Bréb.
Sphærozosma excavatum, Ralfs.
" serratum, B.
" pulchrum, B.
Spirotænia condensata, Bréb.
Staurastrum aristiferum, Ralfs.
" gracile, Ralfs.
" margaritaceum, Ehr.
" tricorne, Bréb.
Triploceras verticillatum, Bréb. Pl. 1, fig. 9.
" gracile, B. Pl. 1, fig. 10.
Tetmemorus Brebissonii, Ralfs.
Xanthidium armatum, Bréb.
" fasciculatum, Ehr.
" octocorne, Ralfs.

—

*Aporea ambigua, B. Pl. 3, fig. 3.

PONDS AT ENTERPRISE.—*continued.*

INFUSORIA.

Arcella aculeata, Ehr.
Conochilus volvox, Ehr. Pl. 3, fig. 2.
Dinobryon sertularia, Ehr.
Gonium glaucum, Ehr.
Hydatina senta, Ehr.
Lacinularia socialis, Ehr.
*Melicerta nuda, B. Pl. 3, figs. 8, 10.
" ringens, Schrank.
*Peridinium carolinianum, B. Pl. 3, figs. 4, 5.
Philodina aculeata, Ehr.
Philodina vestita, B. Pl. 3, figs. 9 and 14.
Rotifer macrourus, Ehr.
" pannosus, B. Pl. 3, figs. 6, 7.
" vulgaris, Schr.
Spirostomum ambiguum, Ehr.
Stephanoceros Eichhornii, Ehr.
—
*Diatoma stellaris, B.
Tabellaria fenestratum, Ehr.

SULPHUR SPRINGS NEAR ENTERPRISE, ETC., FA.

The enormous sulphur springs of Florida are among the most remarkable of the features of this interesting region. They are often from fifty to one hundred feet in diameter, and as many in depth, and pour out bold streams of sulphuretted water of such magnitude that large boats may proceed up them directly into the basins of the springs. The sulphur springs at Orange Spring, (Pearson's), the Blue Spring on the St. John's, and the Green Spring at Enterprise, are the most remarkable which I saw. In all of these I noticed immense quantities of an Oscillatoria which, I believe, is the O. terebriformis of Agardh, with the description of which in Kützing's Species Algarum, p. 239, it agrees perfectly. Its very active vermiform and spiral motions I observed very frequently while at Enterprise. It is accompanied at the springs by a white plant, generally more or less coated with sulphur, which appears to be the Beggiatora raineriana of Meneghini. (See Kützing, l. c. p. 237.) In my notes I have recorded the following forms as found in Demaster's Sulphur Spring, " close to the Boil."

Closterium acerosum, Schr.
—
*Amphiprora pulchra, B.
Eunotia gibba, Ehr.
Navicula cuspidata, Kg.
Navicula elongata, (?)
Pinnularia viridis, Ehr.
Beggiatora raineriana, Menegh.
Oscillatoria terebriformis, Ag.

ADDITIONAL OBSERVATIONS IN GEORGIA.

On my return from Florida, I visited the interior of Georgia, hoping to have an opportunity of comparing the inland microscopical forms with those of the coast which I had previously studied. I was disappointed, however, by the almost constant rains, which in the hilly or mountainous regions produced freshets which swept away everything living in the streams, or buried them in mud. I have, therefore, only to record the species noticed at two localities.

MACON, GA.

May 6th, 1850.—In a mill-pond on the road to Brown's Mount, near Macon, Ga., I found the following species, viz:

Desmidieæ.

Arthrodesmus convergens, Ehr.
Closterium moniliferum, Ehr.
Cosmarium margaritiferum, Menegh.
" ovale, Ralfs.
" pyramidatum, Bréb.
Desmidium quadrangulatum, Ralfs.
Didymocladon furcigerus, Ehr.
Euastrum elegans, Bréb.
" rostratum, Ralfs.
" sublobatum, Bréb.
" verrucosum, Ehr.
Micrasterias denticulata, Bréb.
" furcata, Ag.
" truncata, Bréb.
Pediastrum boryanum, Menegh.
" heptactis, Menegh.
" ellipticum, Hassall.

Desmidieæ.

Pediastrum tetras, Ralfs
Penium digitus, Bréb.
*Sphærozosma serratum, B.
Staurastrum cyrtocerum, Bréb.
" gracile, Ralfs.

—

Infusoria, etc.

Arcella dentata, Ehr.
Dinobryon sertularia, Ehr.
Euglena pleuronectes, Ehr.
Pterodina patina, Ehr.
Rotifer vulgaris, Schr.

—

Algæ.

*Aporea ambigua, B.
Bulbochæte setigera, Ag.

ATHENS, GA.

The following species were collected on the 20th of May, near Athens, Ga. viz:

Desmidieæ.

Closterium lunula, Ehr.
" moniliforme, Ehr.
" turgidum, Ehr.
Desmidium Swartzii, Ag.
Didymocladon furcigerus, Ralfs.
Docidium clavatum, Kütz.
Euastrum oblongum, Ralfs.
" verrucosum, Ehr.
Micrasterias papillifera, Bréb.
" pinnatifida, Ehr.
Penium digitus, Ehr.
Staurastrum orbiculare, Ehr.

Desmidieæ.

Staurastrum muticum, Bréb.
Spirotænia condensata, Bréb.

—

Infusoria, etc.

Amœba princeps.
Arcella angulata.
Cocconema cymbiforme.
Difflugia proteiformis.
* " spiralis, B.

—

Pinnularia viridis, Ehr.

NORTHERN LOCALITY, NEAR PROVIDENCE, R. I.

For the sake of comparison with the above lists of Southern forms, I give here the names of the species noticed by me in Wainskut Pond, near Providence, R. I., on the 12th of July, 1850.

Desmidieæ.

Ankistrodesmus falcatus, Corda.
Arthrodesmus convergens, Ehr.
Cosmarium ovale, Ralfs.
" undulatum, Corda.
Closterium Dianæ, Ehr.
" angustatum, Kg.
" lineatum, Ehr.
" Jenneri, Ralfs.
" moniliferum, Ehr.
Docidium nodulosum, Bréb.
Desmidium Swartzii, Ag.
" quadrangulatum, Ralfs.
Didymoprium Borreri, Ralfs.
Euastrum ansatum, Ehr.
" circulare, Hass.
" didelta, Ralfs.
" elegans, Bréb.
" gemmatum, Kg.
" oblongum, Ralfs.
" rostratum, Ralfs.
" verrucosum, Ehr.
Hyalotheca dissiliens, Bréb.
Micrasterias pinnatifida, Kg.
" truncata, Bréb.
" denticulata, Bréb.
" rotata, Ralfs.
Penium digitus, Bréb.
" margaritaceum, Bréb.
Pediastrum pertusum, Kg.
" boryanum, Menegh.
" ellipticum, Hass.
" heptactis, Menegh.
" tetras, Ralfs.
" selenæa, Kg.

Desmidieæ.

Scenedesmus obliquus, Kg.
" obtusus, Meyen.
" quadricauda, Bréb.
Sphærozosma excavatum, Ralfs.
Staurastrum alternans, Bréb.
" gracile, Ralfs.
" hirsutum, Ehr.
Spirotænia condensata, Bréb.
Tetmemorus Brebissonii, Ralfs.
Xanthidium fasciculatum, Ehr.

—

Diatomaceæ.

*Diatoma stellaris, B.
Eunotia serra, Ehr.
Himantidium arcus, Ehr.
Gomphonema acuminata, Ehr.
Tabellaria flocculosa, Ehr.
" fenestrata, Ehr.

—

Infusoria.

Arcella vulgaris, Ehr.
Brachionus Bakeri, Ehr.
Coleps hirtus, Ehr.
Difflugia proteiformis, Ehr.
" spiralis, B.
Dinobryon sertularia, Ehr.
Euglena viridis, Ehr.
" pleuronectes, Ehr.
Floscularia ornata, Ehr.
Melicerta ringens, Schr.
Peridinium cinctum, Ehr.
Rotifer macrourus, Ehr.
" vulgaris, Ehr.
Stentor polymorphus, Ehr.

See also in the Appendix a list of forms found near Salem, Mass., by Thomas Cole, Esq.

By consulting the above lists, the species found at each locality will be seen. The following tables will show the same in a more condensed form, and will also exhibit the geographical distribution of species.

TABLE A.

SHOWING THE GEOGRAPHICAL DISTRIBUTION OF THE SPECIES OF DESMIDIEÆ INCLUDED IN THE PRECEDING LISTS. THEIR OCCURRENCE AT ANY LOCALITY IS INDICATED BY +.

NAMES OF SPECIES. Species marked with * are believed to be new, and are described at page 36.	LOCALITIES. Vicinity of Charleston, S. C.	Vicinity of Grahamville, S. C.	Vicinity of Savannah, Ga.	Bryan Co., Ga.	Glynn Co., Ga.	Macon and Athens, Ga.	Pilatka and Road to Tampa, Florida.	Vicinity of Enterprise, Florida.	Vicinity of Providence, R. I.
Ankistrodesmus falcatus, Corda	+	+	+	+	+	+	+	+	+
Aptogonum Baileyi, Ralfs	....	....	+	....	....	....	....	....	....
" desmidium, Ehr	....	+	+	+	....	....	....	....	....
Arthrodesmus convergens, Ehr	+	+	....	+	....	+	+	....	+
" incus, Bréb	+	....	....	+	....	....	+	....	....
Closterium acerosum, Schr	+	+	....	+	....	....	+	....	....
" amblyonema, Ehr	....	....	....	....	....	....	....	....	+
" angustatum, Kg	....	....	....	....	....	....	....	....	+
" Dianæ, Ehr	....	....	....	....	+	....	+	....	+
" Ehrenbergii, Menegh	....	....	....	+	....	....	+	....	....
" Jenneri, Ralfs	....	....	....	....	....	....	....	....	+
" lanceolatum, Kg	....	....	....	....	+	....	....	....	....
" Leiblenii, Kg	....	....	....	+	....	....	....	....	+
" lunula, Ehr	....	+	....	....	+	....	....	+	....
" moniliferum, Ehr	....	....	....	....	+	....	....	....	+
" setaceum, Ehr	....	+	+	+	....	....	....	+	+
" turgidum, Ehr	....	....	....	....	....	....	+	+	+
Cosmarium amœnum, Bréb	....	....	....	....	....	....	....	+	....
" Broomei, Thwaites,	....	....	+	....	....	....	....	....	....
" connatum, Bréb	....	....	....	....	....	....	+	....	....
" cucumis, Corda,	....	+	+	....	....	....	....	+	....
* " depressa, B. Pl. 1, fig. 1,	....	....	....	....	....	....	+	+	....
" margaritiferum, Menegh	+	....	....	....	....	....	+	....	....
" ornatum, Ralfs	....	....	....	....	....	....	+	....	....
" ovale, Ralfs	....	+	....	....	....	....	....	....	+
" pyramidatum, Bréb	....	....	+	....	....	....	+	+	....
" Thwaitesii, Ralfs	....	....	....	....	....	....	+	....	....
" undulatum, Corda	+	....	....	....	....	....	....	....	+
Desmidium Swartzii, Ag	....	+	+	....	+	+	....	....	+
" quadrangulatum, Ralfs	....	....	....	....	....	....	....	+	+
Didymocladon furcigerus, Ralfs	....	+	....	....	....	....	+	+	+
* " cerberus, B. Pl. 1, figs. 15, 16,	....	....	....	....	....	....	+	+	....
* " longispinus, B. Pl. 1, fig. 17,	....	....	....	....	....	....	....	+	....
Did[illegible]m Borreri, Ralfs	....	+	....	+	....	....	+	....	+
[illegible]villii, Ralfs	....	+	+	....	....	....	....	....	....
Docidium [illegible]éb	....	....	+	....	....	....	....	....	....
" cla[illegible], Kg	....	+	....	....	+	+	....	....	....
" constric[illegible], B	....	....	+	....	....	....	....	....	....
" Ehrenbergii, Ralfs	....	+	....	+	....	....	+	....	....
* " hirsutum, B. Pl. [illegible] fig. 8,	....	....	....	....	....	....	+	....	....
" minutum, Ralfs. Pl. 1, fig. 3,	....	+	....	....	....	....	+	....	....
" nodosum, B. Pl. 1, fig. 4,	....	....	+	....	....	....	....	....	+
" nodulosum, Bréb	+	+	....	+	....	....	+	....	+
* " undulatum, B. Pl. 1, fig. 2,	....	....	....	....	....	....	....	+	....
" verrucosum, B	....	....	+	+	....	....	....	....	+
Euastrum affine, Ralfs	....	+	....	+	....	....	....	....	....
" ampullaceum, Ralfs	+	....	....	....	....	....	+	+	....
" ansatum, Ehr	....	+	....	....	....	....	....	....	+
" binale, Ehr	....	....	....	....	....	....	+	....	....

TABLE A.—*Continued.*

NAMES OF SPECIES.	LOCALITIES.								
	Vicinity of Charleston, S. C.	Vicinity of Grahamville, S. C.	Vicinity of Savannah, Ga.	Bryan Co., Ga.	Glynn Co., Ga.	Macon and Athens, Ga.	Pilatka and Road to Tampa, Fa.	Vicinity of Enterprise, Fa.	Vicinity of Providence, R. I.
Euastrum circulare, Hass.	....	....	....	....	....	....	....	....	+
" crassum, Bréb.	....	....	+	....	....	....	....	+	....
" didelta, Ralfs.	....	+	+	....	....	....	....	....	+
" elegans, Breb.	+	....	+	....	....	+	+	+	+
" gemmatum, Kg.	....	....	....	....	....	....	....	....	+
" insigne, Hass.	....	....	....	....	....	....	....	+	+
" muricatum, B.	....	....	+	....	....	....	....	....	+
" oblongum, Ralfs.	....	....	....	....	....	....	....	....	+
" rostratum, Ralfs.	....	....	+	+	....	+	....	+	+
" sublobatum, Bréb.	....	....	....	....	+	+	+	+	+
" verrucosum, Ehr.	....	+	....	....	....	+	....	+	+
Hyalotheca dissiliens, Bréb.	....	+	....	....	....	....	+	+	+
*Micrasterias arcuata, B. Pl. 1, fig. 6,	....	....	....	....	....	....	+	+	....
" americana, Ralfs.	....	+	+	+	....	....	+	....	+
" Baileyi, Ralfs.	....	+	....	....	....	....	....	+	+
" crenata, Bréb.	....	+	....	+	+	....	+	....	+
" denticulata, Bréb.	....	+	....	+	....	+	....	+	+
* " expansa, B. Pl. 1, fig. 7,	....	....	....	....	....	....	+	+	....
" fimbriata, Ralfs	....	+	....	....	....	....	....	+	....
" furcata, Ag.	....	+	....	....	....	+	+	....	+
" incisa, Kg. Pl. 1, fig. 13,	....	+	....	+	....	....	+	....	+
" oscitans, Ralfs. Pl. 1, fig. 19,	....	....	....	....	....	....	+	....	+
" papillifera, Bréb.	....	....	....	....	....	....	....	+	+
" pinnatifida, Kg. Pl. 1, fig. 12,	....	+	....	....	....	+	+	+	+
* " quadrata, B. Pl. 1, fig. 5,	....	....	....	....	....	....	+	....	....
" radiosa, Ag.	....	....	....	....	....	....	+	....	+
* " ringens, B. Pl. 1, fig. 11,	....	....	....	....	....	....	+	....	....
" rotata, Ralfs.	....	+	+	+	....	....	....	+	+
" truncata, Bréb. Pl. 1, fig. 20,	....	....	....	....	....	+	+	....	+
Pediastrum boryanum, Menegh.	....	....	....	....	....	+	+	....	+
" ellipticum, Hass.	+	....	....	....	....	+	....	....	+
" heptactis, Menegh.	+	....	....	+	....	+	+	....	+
" napoleonis, Menegh.	+	....	....	....	....	....	....	....	+
" pertusum, Kg.	....	....	....	....	....	....	....	....	+
" selenæa, Kg.	....	....	....	....	....	....	....	....	+
" tetras, Ralfs.	....	....	....	....	....	+	....	....	+
Penium Brebissonii, Ralfs.	....	+	....	....	....	....	....	+	....
" closteroides, Ralfs.	....	+	....	....	....	....	....	....	....
" digitus, Ralfs.	+	+	....	....	+	+	+	+	+
" interruptum, Ralfs.	....	+	....	....	....	....	....	....	....
" Jenneri, Ralfs.	....	....	....	....	....	....	....	+	....
" margaritaceum, Bréb.	....	....	....	....	....	....	....	+	+
Scenedesmus acutus, Meyen,	....	....	....	....	....	....	....	....	+
" obliquus, Kg.	+	+	....	+	....	+	....	....	+
" obtusus, Meyen,	....	....	....	....	+	....	....	....	+
" quadricauda, Bréb.	....	....	....	....	....	....	....	....	+
Sphærozosma excavatum, Ralfs.	+	....	+	....	....	....	+	+	+
" pulchrum, B.	....	....	....	....	....	....	....	+	+
* " serratum, B. Pl. 1, fig. 14,	+	+	+	+	....	....	+	+	....
Spirotænia condensata, Bréb.	....	+	....	....	....	....	+	+	+
Staurastrum alternans, Bréb.	....	....	....	....	....	+	....	....	+
" aristiferum, Ralfs.	....	....	....	....	....	....	....	+	....
" cyrtocerum, Bréb.	....	....	....	....	....	+	....	....	....

TABLE A.—*Continued.*

NAMES OF SPECIES.	LOCALITIES.								
	Vicinity of Charleston, S. C.	Vicinity of Grahamville, S. C.	Vicinity of Savannah, Ga.	Bryan Co., Ga.	Glynn Co., Ga.	Macon and Athens, Ga.	Pilatka and Road to Tampa, Fa.	Vicinity of Enterprise, Fa.	Vicinity of Providence, R. I.
Staurastrum dejectum, Bréb.	....	....	....	....	+	....	+	....	....
" enorme, Ralfs. Pl. 1, fig. 18,	....	....	....	....	....	....	....	+	....
" gracile, Ralfs.	+	....	....	+	....	....	+	+	+
" hirsutum, Ehr.	....	....	....	....	....	....	+	+	+
" margaritaceum, Ehr.	....	+	....	....	....	+	....	+	+
" muticum, Bréb.	....	+	....	....	....	....	....	....	+
" orbiculare, Ehr.	....	....	....	....	....	....	....	....	+
" polymorphum, Bréb.	....	....	....	....	....	....	+	....	....
" tricorne, Bréb.	....	....	....	....	....	....	+	+	....
Tetmemorus Brebissonii, Ralfs.	....	+	....	....	....	....	+	+	+
" granulatus, Ralfs.	....	+	....	....	....	....	....	....	....
*Triploceras verticillatum, B. Pl. 1, fig. 9,	....	....	+	....	....	....	....	+	+
* " gracile, B. Pl. 1, fig. 10,	....	....	+	....	....	....	....	+	+
Xanthidium aculeatum, Ehr.	....	....	....	+	....	....	....	....	....
" armatum, Bréb.	....	+	....	....	....	....	+	....	....
" cristatum, Bréb.	+	+	+	....	....	....	+	....	....
" fasciculatum, Ehr.	....	+	....	....	....	+	+	+	+
" octocorne, Ralfs.	....	....	....	....	....	....	+	....	+

Full descriptions and accurate figures of all these except the new ones marked with *, may be found in Ralfs' beautiful volume, the "British Desmidieæ."

TABLE B.

SHOWING THE GEOGRAPHICAL DISTRIBUTION OF THE SPECIES OF DIATOMACEÆ INCLUDED IN THE PRECEDING LISTS.

NAMES OF SPECIES. N. B. The species in the columns marked F were found in fresh water having no communication with the ocean; those in the columns marked M were either found in salt water, or in localities having a connection more or less remote with the ocean.	LOCALITIES. Vicinity of Charleston, S. C		Vicinity of Grahamville, S. C		Vicinity of Savannah, Ga.		Bryan Co., Ga.		Glynn Co., Ga.		Macon and Athens, Ga.		Pilatka and Road to Tampa, Fa.		Vicinity of Tampa, Fa.		Vicinity of St. Augustine, Fa.		Volusia, Fa.		Vicinity of Enterprise, Fa.		Hudson River, West Point.	
	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.
*Achnanthes? arenicola, B. See Pl. 2, fig. 19,																+								
" brevipes, Ag.		+														+								
" longipes? Ag. See Pl. 2, fig. 1,		+																						
Actiniscus sirius, Ehr.		+																						
Actinocyclus bioctonarius, Ehr.		+																						
Actinoptychus senarius, Ehr.		+				+		+		+								+						+
" denarius, Ehr.						+		+		+														
" duodenarius, Ehr.																		+						
Amphiprora alata, Ehr. See Pl. 2, figs. 5, 6, 7,																+		+						
" constricta, Ehr. Pl. 2, figs. 8, 9, 10,																+						+		+
* " ornata, B. Pl. 2, figs. 15 and 23,														+										
* " pulchra, B. Pl. 2, figs. 16 and 18,																						+		+
* " quadrifasciata, B. Pl. 2, figs. 2, 3, 4,																+								
*Amphora amphyoxys, B. Pl. 2, figs. 20, 21, 22,																		+						
" libyca, Ehr. Pl. 2, fig. 12,		+				+														+				
Bacillaria paradoxa, Ehr.		+		+		+										+				+		+		+
Biddulphia pulchella, Gray		+																						+
*Campylodiscus argus, B. Pl. 2, figs. 24, 25,										+						+						+		+
" clypeus, Ehr.																						+		
*Cerataulus turgidus, Ehr. Pl. 2, figs. 26, 27,																+								+
Ceratoneis closterium, Ehr. Pl. 2, fig. 17,																		+						+
" fasciola, Ehr.		+																						+
Cocconeis pediculus, Ehr.													+							+				
" scutellum, Ehr.		+																		+				+
Cocconema cymbiforme, Ehr.					+				+				+							+		+		+
Coscinodiscus excentricus, Ehr.		+				+		+										+						+
" lineatus, Ehr.		+																+						+
" oculis-iridis, Ehr.										+								+						+
" radiatus, Ehr.						+				+								+						+
" subtilis, Ehr.				+		+		+		+								+						+
Denticella? tridentata, Ehr. (=Zygoceros Tuomeyi, Bailey,)																		+						
Diatoma Ehrenbergii? See Pl. 2, figs. 30, 31,	+												+											
" stellata, B.			+																		+			
Dictyocha fibula, Ehr.		+				+		+										+						+
Eunotia amphioxys, Ehr.									+															
" gibba, Ehr.									+				+							+				+
" librile, Ehr.									+											+	+			
" nodosa, Kg.																				+				
" tetraodon, Ehr.			+						+															+
Eupodiscus Baileyi, Ehr.					+											+		+						
" Rogersii, Ehr.		+				+				+						+		+						
* " radiatus, B.		+				+										+		+						
Fragillaria pectinalis, Ehr.									+															
Gallionella aurichalcea, Ehr.			+		+		+		+											+				+
" sulcata, Ehr.		+				+		+		+						+		+						+
" varians, Ehr. (M. arenaria, Moore,)						+														+				
Gomphonema acuminatum, Ehr.													+											
" constrictum, Ehr.									+															
Grammatophora marina, Ehr.		+														+		+						+
Himantidium arcus,	+		+						+				+					+					+	+
" bidens, Ehr.			+										+				+							
Licmophora radians, Kg.		+																						
Naunema, undetermined,						+																		
Navicula amphigompha, Ehr.																	+							
" amphirhynchus, Ehr.						+																		
" baltica,				+												+		+						+

TABLE B.—*Continued.*

NAMES OF SPECIES.	LOCALITIES. Vicinity of Charleston, S. C.		Vicinity of Grahamville, S. C.		Vicinity of Savannah, Ga.		Bryan Co., Ga.		Glynn Co., Ga.		Macon and Athens, Ga.		Pilatka and Road to Tampa, Fa.		Vicinity of Tampa, Fa.		Vicinity of St. Augustine, Fa.		Volusia, Fa.		Vicinity of Enterprise, Fa.		Hudson River, West Point.	
	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.
Navicula cuspidata ? Pl. 2, figs. 29 and 37,													+								+			
" elongata, (of the English,)																				+		+		+
" hippocampus, Ehr.					+		+											+						+
" sigma, Ehr.		+																+						+
Odontella polymorpha, Kg.																+		+				+		+
Pinnularia amphigompha, Ehr.			+																					
" amphioxys, Ehr.		+								+														
* " Couperi, B. Pl. 2, fig. 33,																		+						
" didyma, Ehr.																+								+
" elliptica, Kg.			+			+																		
" iridis, Ehr.			+																					
" interrupta, Kg.				+				+		+								+						+
" lyra, Ehr.		+				+																		
* " permagna, B. Pl. 2, figs. 28 and 38,																						+		+
" placentula, Ehr.						+																		
" viridis, Ehr.	+						+		+	+								+						+
*Pyxidicula ? compressa, B.				+						+								+						
Rhabdonema adriaticum, Kg.																		+						+
Rhaphoneis rhombus, Ehr.		+				+		+		+								+						
Rhipidophora crystallina, Kg.																		+						
Schizonema quadripunctata, Ag.																		+						
*Stauroneis maculata, B. Pl. 2, fig. 32,																						+		
Stauroptera aspera, Ehr.		+														+		+						
*Surirella circumsuta, B. Pl. 2, fig. 36,		+																+						+
" ovalis, Ehr.														+										
" splendida, Ehr.	+		+			+		+	+		+		+								+			+
Synedra scalaris, Ehr.																					+	+		
" spectabilis, Ehr.								+																
" valens, Ehr.	+							+																
" vitrea, Kg.					+		+		+				+	+						+				
Tabellaria flocculosa, Ehr.			+																		+			
" fenestratum, Ehr.			+																		+			
Terpsinoë musica, Ehr.		+				+		+		+				+				+		+		+		
Triceratium favus, Ehr.		+				+		+		+				+				+						+
" alternans, B.		+				+		+		+								+						+
" obtusum, Ehr,						+																		
" reticulum, Ehr.								+		+								+						
*Zygoceros (Denticella ?) Mobilensis, B. Pl. 2, figs. 34 and 35,						+												+						
Zygoceros rhombus, Ehr.		+				+				+								+						+

Such of the above species as are not indicated as new, will be found described in Ehrenberg's "Verbreitung und Einfluss des mik, Lebens in S. und N. America," and in Kützing's "Bacillarien, oder Diatomeen." For a description of the new species, see page 38.

TABLE C.

SHOWING THE GEOGRAPHICAL DISTRIBUTION OF THE INFUSORIA INCLUDED IN THE PRECEDING LISTS.

NAMES OF SPECIES. The names here adopted are those given in Pritchard's Infusoria. They are mostly on the authority of Ehrenberg.	Localities.											
	Vicinity of Charleston, S C.	Vicinity of Grahamville, S. C.	Vicinity of Savannah, Ga.	Bryan Co., Ga.	Glynn Co., Ga.	Macon and Athens, Ga.	Pilatka and Road to Tampa, Fa.	Vicinity of Tampa, Fa.	Vicinity of St. Augustine, Fa	Volusia, Fa.	Vicinity of Enterprise, Fa.	Vicinity of Providence, R. I.
Acineta Lyngbyii,									+			
" mystacina. Pl. 3, fig. 22,							+					
Actinophrys viridis,			+									
Amœba princeps,		+					+			+	+	+
Amblyophis viridis,	+											
Amphileptas anser,		+									+	
Arcella aculeata,							+				+	+
" dentata,	+			+		+	+				+	
" hyalina,		+									+	
" vulgaris,	+	+	+	+			+					+
Brachionus urceolaris. Pl. 3, fig. 17,									+		+	
" polyacanthus. Pl. 3, f. 20, 21,											+	
Carchesium polypinum,								+				
Colurus tricuspidatus,							+					
Conochilus volvox. Pl. 3, fig. 2,											+	
Cothurnia Havniensis. Pl. 3, fig. 18,								+				
" imberbis. Pl. 3, fig. 23,							+				+	
" maritima. Pl. 3, figs. 11, 15,								+				
Difflugia proteiformis,		+										+
" spiralis, B.		+									+	+
Dinobryon sertularia,		+	+			+					+	+
Dinocharis tetractis,											+	
Epistylis anastatica,		+										
Euglena pleuronectes,	+			+			+				+	+
" viridis,	+			+							+	+
Floscularia ornata,											+	+
Gonium glaucum,			+				+				+	
" pectorale,					+							+
Hydatina senta,		+			+						+	+
Lacinularia socialis,					+						+	
Lepadella ovalis,	+											
Melicerta ringens,											+	+
* " nuda, B. Pl. 3, figs. 8 and 10,											+	
Megalotrocha alboflavicans,		+					+				+	
Metopidia lepadella,							+					
Monostyla lunaris,	+						+		+			
Noteus quadricornis,							+					
Notommata longiseta,											+	
Œcistes crystallina,											+	
Opercularia articulata,											+	
Ophrydium versatile,		+			+							
*Peridinium carolinianum, B. Pl. 3, f. 4, 5,		+	+		+						+	
" cinctum, Ehr.	+	+	+	+	+		+				+	+
Philodina erythropthalma,											+	
" vestita, B. Pl. 3, figs. 9, 14,											+	
Pterodina patina,		+				+	+					
* " magna, B. Pl. 3, fig. 19,									+			
Rotifer macrourus,			+								+	+

TABLE C.—*Continued.*

NAMES OF SPECIES.	Localities.											
	Vicinity of Charleston, S. C.	Vicinity of Grahamville, S. C.	Vicinity of Savannah, Ga.	Bryan Co., Ga.	Glynn Co., Ga.	Macon and Athens, Ga.	Pilatka and Road to Tampa, Fa.	Vicinity of Tampa, Fa.	Vicinity of St. Augustine, Fa.	Volusia, Fa.	Vicinity of Enterprise, Fa.	Vicinity of Providence, R. I.
Rotifer vulgaris,	+	+	+	+	+	+	+	....	....	+	+	+
* " pannosus, B. Pl. 3, figs. 6, 7,	....	....	....	+	....	....	....	....	....	....		....
Salpina mucronata,	....	....	....	....	....	....	+	....	....	....	....	....
Scaridium longicaudum,	....	+	....	....	....	....	....	....	....	....	+	....
Spirostomum ambiguum,	....	....	....	....	....	....	....	....	....	....	+	+
Squamella oblonga,	+	....	....	....	....	....	....	....	....	....	....	....
Stentor polymorphus,	....	+	+	+	....	....	+	....	....	....	+	+
Stephanoceros Eichhornii. Pl. 3, fig. 13,	....	....	....	....	....	....	....	....	....	....	+	+
Stylonychia mytilus,	....	....	....	....	....	....	+	....	....	....	....	....
Synura uvella,	....	+	+	....	+	....	....	....	....	....	....	+
Vaginicola crystallina,	....	....	....	+	....	....	+	....	....	....	....	....
Vorticella chlorostigma,	....	+	....	....	....	....	....	....	....	....	+	....
" nebulifera,	....	....	....	....	....	....	....	....	....	....	+	....

Descriptions of most of the above species, with figures and copious lists of synonyms, may be found in Ehrenberg's splendid volumes, "Die Infusionthierchen," and accounts abridged from the same work are given in Pritchard's "Infusoria, Living and Fossil." The latter work was the one I had with me in my Southern tour.

NOTE. In the preceding tables I have separated the Desmidieæ and Diatomaceæ from the Infusoria, and I have done so because many distinguished observers now consider these groups as decidedly belonging to the vegetable kingdom. While I believe that no accurate line of separation can be drawn between vegetables and animals, I am yet disposed to consider the Desmidieæ, from the sum of all their characters, as most nearly allied to admitted vegetables, while the Diatomaceæ, notwithstanding Thwaites' interesting observations on their conjugation, still seem to me, as they have always done, to be true animals. There is such apparent volition in their movements, such an abundance of nitrogen in the composition of their soft parts, and such resemblances between the stipitate Gomphonematæ, and some of the Vorticellæ, that I should still be disposed to class them as animals, even if Ehrenberg's observations of the retractile threads and snail-like feet of some of the Naviculæ should not be confirmed.

TABLE D.

LIST OF ALGÆ REFERRED TO IN THE PRECEDING PAGES, WITH LOCALITIES.

Aporea ambigua, B. Occurs everywhere in the lakes and ditches of the Southern States.
Bangia fusco-purpurea, Dillw. Tampa, Fa.
Batrachospermum moniliforme, Roth. Big Hillsborough River, Fa.
Botrydium argillaceum, Wall. Near Savannah, Ga.
Bulbochæte setigera, Ag. Common throughout the United States.
Ceramium clavulatum, Ag. Tampa.
Chætophora pisiformis, Ag. Common.
Coleochæte scutata, Bréb. In lakes, &c., from Massachusetts to Florida. Very abundant in a pond on Anastasia Island, near St. Augustine.
Delesseria hypoglossum. Near Wilmington, N. C., Charleston, S. C., and St. Augustine, Fa.
" Leprieurii, Mont. An estuary species found first in Cayenne, South America, afterwards in the Hudson River, at West Point, N. Y., and on this tour in the Ashley, Savannah, Ogeechee, Altamaha, St. Sebastian, and Hillsborough rivers, usually accompanied by a large species of Bostrichia.
Ectocarpus littoralis, L. Common.
Gelidium corneum, Huds. St. Augustine.
Gracilaria multipartita, Clem. St. Augustine and Tampa.
Laurencia dasyphylla, Woodw. St. Augustine.
Mougeotia genuflexa, Ag. Hopeton, Ga., Warm Springs and St. Augustine, Fa.
Oscillatoria terebriformis, Ag. Abounds in the sulphur springs of Florida, and in the streams issuing from them. The motion of the filaments is very active.
Polysiphonia Olneyi? Harv. Tampa.
Porphyra vulgaris, Ag. Charleston, S. C., St. Augustine, Fa.
Rhabdonia Baileyi, Harv. Very large specimens are common at St. Augustine.
Sargassum vulgare, Ag. Tampa.
Spirogyra, (Zygnema, Ag.) quinina, Kg. } Common everywhere.
" decimina, Kg. }
Spiridia filamentosa, Wulf.
Tetraspora lubrica, Ag. Grahamville, S. C.
Vaucheria cespitosa, D. C. Common.
" racemosa. Near Savannah, Ga.
Ulva latissima, L.

DESCRIPTION

OF THE NEW SPECIES, REFERRED TO IN THE PRECEDING LISTS.

DESMIDIEÆ.

1. Cosmarium depressum, B. Pl. 1, fig. 1. Elliptical, binate, division in the plane of the longest axis. Segments entire, nearly twice as long as broad, rounded above, very much flattened at base.

Hab. Lakes in Florida.

This species resembles C. bioculatum, Bréb., but the segments are much closer together, and are angular, not rounded at the basal extremities.

2. Didymocladon? cerberus, B. Pl. 1, fig. 15 and 16. Small, deeply constricted, segments three-lobed, lobes with four teeth, two of which project upwards and two downwards at each truncated angle.

Hab. Lakes in Florida.

3. Didymocladon? longispinum, B. Pl. 1, fig. 17. Large, smooth, triangular, with two long spines at each angle.

Hab. Lakes in Florida.

The two last species are not very nearly allied to each other, nor to the typical D. furcigerus, yet they agree better with the verbal characters of the genus than with those of any other known to me; I therefore refer them here provisionally.

4. Docidium hirsutum, B. Pl. 1, fig. 8. Segments many times longer than broad, slightly inflated at base, surface hirsute.

A small species resembling D. Ehrenbergii in form, but strongly hirsute on its outer surface.

Hab. Lakes in Florida, at Enterprise.

5. Docidium undulatum, B. Pl. 1, fig. 2. Segments eight to ten times longer than broad, constricted six to eight times at regular intervals throughout their entire length, with the base and ends crenate.

Smaller than D. nodulosum, Bréb., with more frequent and deeper constrictions. The same characters distinguish it from D. nodosum and D. constrictum, B.

6. Micrasterias arcuata, B. Pl. 1, fig. 6. Quadrangular, segments three-lobed, the basal lobes long and arcuate, subtended by the transverse projections from the ends of the slightly notched terminal lobes.

An interesting and very distinct species, which can be confounded with no other except the following.

Hab. Lakes in Florida.

7. Micrasterias expansa, B. Pl. 1, fig. 7. Segments three-lobed, basal lobes long, sub-conical, acute; terminal lobes slender, forked at the end, with the divisions much shorter than the basal lobes.

This somewhat resembles the preceding species, with which it occurs, but I have seen no intermediate forms, out of many hundreds of each, and the characters above given appear sufficient to separate them.

Hab. Lakes in Florida, at Pilatka and Enterprise.

8. Micrasterias quadrata, B. Pl. 1, fig. 5. Large, quadrangular, three-lobed, basal lobes elongated, slightly curved, bidentate; terminal lobes with two slender transverse bidentate projections.

Its larger size and distinctly bidentate projections sufficiently distinguish it from the two preceding species.

Hab. Lakes in Florida.

9. Micrasterias ringens, B. Pl. 1, fig. 11. Oblong, segments three-lobed, coarsely granulated near the edge; basal lobes subdivided by a deep notch into two rather broad and obtuse or slightly bidentate projections; terminal lobes exserted, emarginate; extremities bidentate or obtuse.

Resembles M. Baileyi, Ralfs, but is larger, its divisions less slender, and with the granulations differently placed.

Lakes in Florida, near Dade's Battle Ground.

10. Sphærozosma serratum, B. Pl. 1, fig. 14. Joints broader than long, deeply notched or divided into two transverse portions with acute projecting ends, which give a serrated outline to the chain.

Common in fresh water in South Carolina, Georgia, and Florida.

Triploceras, nov. gen.

Frond binate; segments straight, much elongated, with numerous whorls of knot-like projections; ends of the segments three-lobed; lobes bidentate.

A genus closely allied to Docidium, but differing in the three-parted ends of the segments. Pl. 1, fig. 9.

11. Triploceras verticillatum, (Bailey in lit. cum icone 1847, v. Brit. Desmid. p. 219). Robust, with whorls of emarginate projections. Syn. Docidium verticillatum, Ralfs. l. c. p. 219, Pl. 35, fig. 9 *a*, *b*, *d*, *e*.

Hab. same as next species.

12. Triploceras gracile, B. Pl. 1, fig. 10. Slender, with whorls of rounded projections. Ralfs, l. c. Fig. 9, *c*.

I discovered these forms in Rhode Island, in 1847, and sent sketches of them to Ralfs, who has published an account of them in his British Desmidieæ, p. 219. I then included both forms under the same name, but as I have now seen great numbers of each kind, I think them sufficiently distinct to be separated.

Hab. Worden's Pond, R. I., Princeton, N. J., Georgia and Florida. Abundant in lakes near Enterprise, Fa.

DIATOMACEÆ.

1. Achnanthes? arenicola, B. Pl. 2, fig. 19. Frustules minute, rectangular, or slightly curved; end view lanceolate, striate.

Small plates, composed of two or three frustules, supported by a short pedicel, were found abundantly on grains of the beach sand, below high-water mark, at Fort Brooke, Tampa. It is possibly a species of Hyaloseira, but requires further study.

2. Amphiprora pulchra, B. Pl. 2, figs 16 and 18. Large, deeply constricted, ends rounded, sides compressed, carinate, distinctly striate, and near the margin punctate. Central portion narrow, sigmoid, with a few fine longitudinal lines. Often contorted so as to bring one half into a plane at right angles to the other.

Hab. Beach at Rockaway, Long Island; Hudson River, at Washington's Valley, near West Point, and in great abundance and of large size at Enterprise, Fa. The figures were drawn from Florida specimens collected in the mud of a small creek near Mr. Duval's boarding-house, at Enterprise.

3. Amphiprora ornata, B. Pl. 2, figs. 15 and 23. Small, deeply constricted, ends truncated and rounded, sides marked with a longitudinal row of undulations or pinnulæ, as in Surirella. Often contorted.

The ruffle-like rows of pinnulæ distinguish this species from all others. It probably has minute striæ also, but I did not have an opportunity to examine with high powers.

Hab. Withlacoochee River, where it is crossed by the road from Pilatka to Tampa, Fa.

4. Amphiprora quadrifasciata, B. Pl. 2, figs. 2, 3, 4. Small, moderately constricted, ends truncate or slightly rounded, sides compressed or carinate, lanceolate, with the apices produced and rostellate.

When living, each specimen was marked by four transverse yellow bands. A high power shows the surface to be very minutely striate. No contorted specimens were seen.

Hab. Tampa, and St. Augustine, Fa.

5. Amphora amphioxys, B. Pl. 2, figs. 20, 21, 22. Ventral side rectangular, with slightly rounded ends, and two arcuate bands of striæ, which are broadest near the centre. Back convex, minutely striate. Sides convex above, minutely striate, concave below, strongly striate. Ends produced and rostellate.

The side view of this species bears a striking resemblance to Eunotia amphioxys, Ehr.

Hab. St. Anastasia Island, near St. Augustine, Fa.

6. Campylodiscus argus, B. Pl. 2, figs. 24, 25. Large, circular, and saddle-shaped, surface marked with rows of conspicuous dots; margin smooth, with a row of pinnulæ placed at a short distance from its edge.

A fine, large, and very distinct species, which appears to be widely diffused in the estuaries of the United States. I first found it, several years ago, in the mud of the Hudson River, at West Point, and in mud from the harbor of New Haven, Conn. In Florida I found it at St. Augustine, Tampa, and quite abundant at Enterprise. I also noticed it at Hopeton, on the Altamaha, in Georgia, and the mud from near New Orleans.

7. Cerataulus turgidus, Ehr. Pl. 2, figs. 26, 27. Frustules globular, or slightly compressed, with two large rounded prominences at each end, cohering by alternate angles, forming zigzag chains. Between the two rounded processes, and in a plane at right angles to that containing them, are placed two long horn-like processes.

Two frustules are often connected by an external decussately punctate cell, as in Isthmia and Biddulphia. I first noticed this species at Rockaway, N. J., in the year 1843, and sent it to Ehrenberg, who informed me that he had named it *Cerataulus turgidus*.

I am not aware that any description of it has heretofore been published.

I found it at Tampa; and it also occurs in the Hudson River, at West Point.

8. Diatoma stellaris, B. Frustules rectangular, many times longer than broad, usually in groups of five or six individuals, cohering by the adjacent (not alternate) angles, so as to produce a stellate arrangement. These stellate groups of minute frustules are so common from Rhode Island to Florida, that I am inclined to believe them a distinct species of Diatoma, and have accordingly referred to them by the name of D. stellaris in the preceding pages.

9. Eupodiscus radiatus, B. In form, size, and reticulation resembling the Coscinodiscus radiatus of Ehrenberg, but having four (or more ?) foot-like projections near the margin.

A common form in the Southern States.

10. Pinnularia Couperii, B. Pl. 2, fig. 33. Large, slightly constricted in the middle, with two marginal and two intermediate punctato-striate bands, the latter interrupted at the centre.

The outline is like that of P. paradoxa, Ehr., and the markings somewhat resemble those of P. lyra.

Hab. St. Augustine.

I take great pleasure in dedicating it to James Hamilton Couper, Esq., of Hopeton, whose scientific attainments and generous hospitality are well known to naturalists.

11. Pinnularia permagna, B. Pl. 2, figs. 28 and 38. Large, lanceolate on the ventral faces, with punctato-striate marginal bands, and a broad, smooth central stripe; ends slightly rounded.

Abundant in the Hudson River, at West Point, and occurs, of a smaller size, and much less abundantly, in Lake Monroe, at Enterprise, Fa.

12. Pyxidicula? compressa, B. Pl. 2, figs. 13 and 14. Elliptical, bivalve; valves separated by a plane passing through the longer axis; slightly convex, and with transverse rows of dots.

Hab. St. Augustine.

13. Stauroneis maculata, B. Pl. 2, fig. 32. Lanceolate or elliptical, ends slightly produced and rounded; surface punctato-striate, with a large smooth central space.

Resembles S. punctata of Kützing's Bacillarien, Pl. 21, fig. 9, but is larger, and has the ends not so much produced.

Hab. Enterprise, Florida, where it is common in Lake Monroe, and in several of the smaller creeks near Mr. Duval's.

14. Surirella circumsuta, B. Pl. 2, fig. 36. Outline nearly elliptical, with a scarcely perceptible constriction at the middle. Surface with very minute granulations, and a faint longitudinal line through the middle. Edges with a continuous row of nearly obsolete pinnulæ.

Hab. Hudson River, West Point; St. Augustine and Enterprise, Florida.

15. Triceratium alternans, B. Small, reticulated, triangular; surface marked with three lines, which, with the portions cut off from the sides, form a hexagonal figure.

Common everywhere along the Atlantic coast and in estuaries; also abundant in the fossil state, in the Infusorial strata of Virginia, and in the rice fields of Georgia and Carolina.

16. Zygozeros (Denticella?) mobiliensis, B. Pl. 2, figs. 34 and 35. Frustules quadrangular, compressed, thin, delicately decussatedly-punctate; lateral processes slender; intermediate ones (two at each end) long and slender. Color yellowish.

I first detected this species in 1848, in soundings from Mobile Bay, and subsequently I have found it at Savannah, Ga , and St. Augustine, Florida. It is a curious and interesting form, with the shape of a Zygoceros, and the spines of a Denticella.

INFUSORIA.

1. Difflugia spiralis, B. Lorica subglobose, minutely granulated; upper surface with a spiral suture of two or three turns Pseudopodia long, numerous, constantly changing position.

Very common throughout the United States. M. Le Clerc mentions spiral corrugations as occurring on the D. Proteiformis, Ehr. His remark, doubtless, alludes to the D. spiralis, which, I think, should be distinguished from the other form.

2. Melicerta nuda, B. Pl. 3, figs. 8, 10. This is, possibly, only a condition of M. ringens; but no allusion is made, in the works to which I have access, to any state of that species in which the granules are not present upon the case. Numerous specimens were seen at Enterprise which were evidently full grown, and which contained eggs, and yet the case was perfectly free from granulations, being clear and transparent as glass. I have referred to such specimens by the name of M. nuda.

3. Peridinium carolinianum, B. Pl. 3, figs. 4, 5. Large, processes three ; two on one side, and one on the other of the middle groove. Proboscis in the sinus between two processes. Surface coarsely granulate. Color, yellowish brown.

The proboscis moves very rapidly, sometimes in irregular undulations, and sometimes revolving so rapidly as to produce the appearance of a cone, as represented in the fig. of Peridinium fusus, Ehr., given in Pritchard's Infusoria. Pl. 4, figs. 2, 23. An appearance of an orifice is obscurely seen on the under side, near the insertion of the proboscis. When mounted in Canada balsam, the shell becomes nearly invisible. The motions of the living animal are very active. I could detect no trace of phosphorescence on agitating in the dark a phial which contained myriads of the living animals.

This fine species occurs in vast quantities among the roots of Lemna in the "Back-waters" of rice fields, Grahamville, S. C. I also found it near Savannah and in the lakes of Florida, at Enterprise, Pilatka, &c.

4. Rotifer vestitus, B. Pl. 3, figs. 9 and 14. Body large, elliptical, completely covered by a transparent, jelly-like case, which does not become wrinkled during the motions of the animal.

Hab. Enterprise, Fa.

5. Pterodina magna, B. On St. Anastasia Island, in a small fresh-water pond, I collected a species of Pterodina with a carapace nearly twice as large as any specimens of P. patina which I have ever seen, and differing somewhat in the undulations of its frontal margin. Although it has not yet been sufficiently studied to be accurately described, I give its outline in Pl. 3, fig 19, and have referred to it by the name of P. magna.

6. Philodina pannosa, B. Pl. 3, figs. 6, 7. Body large, covered with irregular wedge-shaped projections, arranged in several longitudinal and transverse rows.

Hab. Enterprise, Fa.

ALGÆ.

1. Aporea ambigua, B. Pl. 3, fig. 3. Frond (?) microscopical, thin, flat, much divided in a dichotomous manner, surface with irregular longitudinal markings; color, brown.

Merely to avoid circumlocution, I have referred by the above name to this constantly occurring form. I know nothing of its real nature; and it is almost as probable that it is the compound support of some of the stipitate infusoria, as that it belongs to the vegetable kingdom. I have never seen either spores or infusoria in connection with it. It occurs everywhere in fresh water in Georgia and Florida.

GENERAL REMARKS.

1. It will be seen by the preceding pages, that 275 species of Desmidieæ, Diatomaceæ, and Infusoria have been positively determined as occurring in regions where not one of them was previously known by direct observation to exist. Of these species, thirty-one, or about one-ninth, are believed to be new, and the others are already known to occur in the Northern States, or in Europe.

2. The identity of many of the northern species of Desmidieæ, &c., with those of Europe, has been known for several years, and we now have evidence that the same is true with regard to the greater number of the forms occurring in Carolina, Georgia, and Florida. We have thus another illustration of the fact, that the microscopical organisms in fresh water are less affected by differences of climate than almost any other portion of the organic world.

3. Almost every locality examined, whether in fresh or salt water, is shown to have been teeming with organic life even in mid-winter.

4. With regard to the degree of reliance to be placed upon my determinations, I may state, that no one could have criticised each observation more rigidly than I have done, and that I was anxious to admit no species into my lists which I could not be perfectly certain was identical with the European or Northern form whose name I might attach to it, while I was equally desirous to record all forms which appeared novel, and which presented characters sufficiently marked to enable other observers to recognize them by my description and figures. I

have, therefore, omitted many forms which I could not determine satisfactorily. My guides in studying these bodies, while on the journey, were Ralfs' British Desmidieæ, a work whose elaborate descriptions and exquisite figures enable the student to determine the species with perfect certainty; Kützing's Diatomaceen oder Bacillarien, which contains many figures of the Diatomaceæ, both by Ehrenberg and Kützing; and "Pritchard's History of Infusoria, Recent and Fossil," which contains abridged descriptions and reduced figures, taken from Ehrenberg's great work, "Die Infusionsthierchen."

5. The existence of vast quantities of infusorial remains in the earth of the rice fields in the Southern States is, perhaps, connected with their wonderful fertility. The fact that the species found are chiefly marine, and such as now abound in the salt marshes of the coast, indicates the former presence of salt water much farther up the rivers than it now extends.

6. Although the species found in the rice fields are such as are still living in estuaries or along the coast, those excavated in digging the deep canals of the rice fields, and the ditches of the forts near Savannah, must have been deposited many hundreds, if not thousands of years ago, and they are, therefore, fully entitled to the name of fossils, and should, I think, be referred to the Post Pleiocene epoch.

7. The vast salt marsh formations of the coast of South Carolina, Georgia, and Florida abound in silicious Diatomaceæ, whose shells are daily becoming imbedded in mud; so that we have here, in the process of formation, deposits similar in character to the infusorial strata of Virginia and Maryland, and quite as extensive, although usually rather more sandy in their character.

8. It will be seen by table B, that certain species of Diatomaceæ which occur in the ocean itself, may also live at great distances from the ocean, in estuaries and rivers far above where the surface water is fresh; yet these same species have *never* been found in lakes or pools of fresh water, not having a direct communication, however remote, with the sea. Among the species of this character are Amphiprora pulchra, B., Amphiprora constricta, Ehr., Amphora libyca, Ehr., Bacillaria paradoxa, Ehr., Ceratoneis closterium, Ehr., Ceratoneis fasciola, Ehr., Coscinodiscus subtilis, Ehr., Cerataulus turgidus, Ehr., Navicula elongata, Odontella polymorpha, Kg., and Terpsinoë musica, Ehr.

9. The beautiful Terpsinoë musica, Ehr., is an interesting addition to our native species of Diatomaceæ. It was first received by Ehrenberg from Mexico, and he has recently proved its existence in the rivers of Texas, (see Monatsbericht der Preuss. Akad. zu Berlin, Feb., 1849, p. 88;) but it was not known to exist in the older States until, by the observations recorded in this memoir, I determined its existence in all our Southern rivers. I have also specimens of it from Jamaica, West Indies, and portions of a closely allied, if not identical form, from Mindanao, in the Phillipine Islands.

10. The observations above recorded will serve to show how abundant a store of organic beings await the researches of naturalists in the Southern States,—forms which, independent of their being among the most delicate and beautiful of all the displays of creative power, are also of the greatest interest, from the important relations which Ehrenberg has proved to exist between them and wide-spread cosmical phenomena.

11. The waters in which I detected the species above recorded, also abounded in many other forms of microscopic life; as, Entomostraca, Tardigradi, Anguilluli, &c., &c. Of these I have made no record, as I did not possess sufficient knowledge concerning them. They will well reward the attention of Southern naturalists.

APPENDIX.

MICROSCOPICAL FORMS FOUND NEAR SALEM, MASS., BY T. COLE, ESQ.

For the following interesting list of microscopical forms found near Salem, Mass., I am indebted to Thomas Cole, Esq., of that place, who has for several years examined these forms with great zeal, and who, I believe, was the first person to make a systematic study of the American soft skinned Infusoria. This list will be useful for the purpose of comparing the forms of the Northern and Southern States. The names employed by Mr. Cole are those used by Ehrenberg, in his large work Die Infusionsthierchen, with the descriptions and figures of which each form was compared.

Volvox sphærosira.
" Globator.
Pandorina Morum.
Synura Uvella.
Closterium striolatum.
" lineatum.
" turgidum.
" setaceum.
" Trabecula.
" Lunula.
Amblyophis viridis.
Docidium nodosum.
" nodulosum.
Euglena acus.
" longicauda.
" Pyrum.
" pleuronectes.
" triquetra.
" spirogyra.
" Deses.
Chlorogonium euchlorum.
Distigma Proteus.
Dinobryon Sertularia.
Amœba princeps.
" radiosa.
Difflugia proteiformis.
Arcella vulgaris.
Naunema simplex.
Desmidium Swartzii.
" quadrangulatum.
" aculeatum.
Staurastrum dilatum.
Xanthidium ramosum.
" aculeatum.
" hirsutum.
" fasciculatum.
Arthrodesmus convergens.
" quadricaudatus.
Odontella Desmidium.
" filiformis.
*Micrasterias heptactis.
" hexactis.
" Boryana.
" tricyclia.
*Euastrum rota.
" Crux Melitensis.
" verrucosum.
" Pecten.
" margaritiferum.
Gallionella moniliformis.
Navicula striatula.
" viridis.
" sigmoidea.
" splendida.
" Baltica.
" diagonalis, (=N. angulata ?)

Eunotia tetraodon.
" pentodon.
" serra.
Synedra ulna.
" capitata.
" lunaris.
Podosphenia gracilis.
Gomphonema acuminatum.
Cyclidium glaucoma.
Peridinium fuscum.
Glenodinium apiculatum.
Stentor Mulleri.
Vorticella nebulifera.
" Campanula.
" Convallaria.
Carchesium polypinum.
Epistylis Galea.
" anastatica.
Cothurnia imberbis.
Actinophrys Sol.
" viridis.
Lacrymaria Proteus.
Coleps hirtus.
Spirostomum ambiguum.
Chilodon Cuculus ?
Trachelocerca Olor.
Amphileptas Anser.
Amphileptas monilifer.
" margaritifer.
" fasciolus ?
Paramecium aurelia.
Uroleptus Filum.
" Piscis.
Oxytricha caudata.
Urostyla grandis.
Stylonychia mytilus.
Trachelius Ovum.
" trichophorus.
Oxytricha caudata.
Chætonotus maximus.
" Larus.
Floscularia proboscidea.
" ornata.
Notommata longiseta.
" copeus.
Scaridium longicaudum.
Lepadella emarginata.
Dinocharis pocillum.
Stephanops lamellaris.
Rotifer vulgaris.
Philodina aculeata.
Urocentrum Turbo.
Euplotes Charon.
" patella.

I have not thought it necessary to change any of the above names to correspond with those which I have adopted. It is necessary, however, to mention that the genus Micrasterias of Ehrenberg is Pediastrum of Meyen, Ralfs, &c., and of my lists, while the Euastrum of Ehrenberg is in part equivalent to the Micrasterias of Agardh, Ralfs, &c., whose names I have used.

J. W. B.

Since this Memoir was in type I have received from Dr. W. C. Daniell, of Savannah, Ga., several specimens of soil from his rice fields, ten miles above Savannah. These prove to be exceedingly rich in the same species of marine silicious Diatomaceæ which occur in the soil of the plantations opposite Savannah. One of Dr. Daniell's specimens appears to be almost entirely made up of perfect shells of Coscinodiscus subtilis, Ehr.

Explanation of Plates.

The figures on these Plates are little more than memorandum sketches, few or none of the details of relief, sculpturing, striation, &c., being given. They are, however, accurate as far as they go, being all, except where otherwise stated, drawn by means of the camera-lucida, from living specimens. They may serve, therefore, to identify the forms referred to in the descriptions.

PLATE I.

Fig. 1. Cosmarium depressum, B.
2. Docidium undulatum, B.
3. " minutum, Ralfs.
4. " nodosum, B.
5. Micrasterias quadrata, B.
6. " arcuata, B.
7. " expansa, B.
8. Docidium hirsutum, B.
9. Triploceras verticillatum, B.
10. " gracile, B.
11. Micrasterias ringens.
12. " pinnatifida, Kg.
13. " incisa, Kg.
14. Sphærozosma serratum, B.

Fig. 15. Didymocladon cerberus, B., side view.
16. " cerberus, B., end view.
17. " longispinum, B.
18. Staurastrum enorme, Ralfs.
19. Micrasterias oscitans, Ralfs, with abnormal teeth at *a* and *b*.
20. Micrasterias denticulata, Ralfs. It has broad and slightly hirsute ends, which I have not seen mentioned as occurring in the British specimens.
21. Scale for all the figures in this Plate, being $\frac{5}{1000}$ths of an inch, magnified equally with the sketches.

PLATE II.

Fig. 1. Achnanthes longipes ? Ag. Charleston.
2. Amphiprora quadrifasciata, B. Tampa.
3. " " seen obliquely.
4. " " side view.
5. " constricta, Ehr. Tampa.
6. " " side view. Tampa.
7. " " Ehr , large specimen. Tampa.
8, 9 Amphiprora alata, Ehr. St. Augustine.
10. " " " a contorted specimen, seen edgewise.
11. Achnanthes, a single frustule, species undetermined. Volusia.
12. Amphora libyca, Ehr.
13. Pyxidicula compressa, B. St. Augustine.
14. " " cross section of one valve.
15. Amphiprora ornata, B. Withlacoochee R.
23. " " " a contorted specimen.
16. " pulchra, B., side view.
18. " " " larger specimen, front view, Enterprise.

Fig. 17. Ceratoneis closterium, Ehr. St. Augustine.
19. Achnanthes ? arenicola, B. Tampa.
20. Amphora amphioxys, B., ventral surface. St. Augustine.
21. " " oblique view.
22. " " side view.
24, 25. Campylodiscus argus, B. Hudson River.
26. Cerataulus turgidus, Ehr. Hudson River, horns absent.
27. Cerataulus turgidus, Ehr., with the horns.
28, 38. Pinnularia permagna, B. Hudson River.
29. Navicula cuspidata ? Ehr. Pilatka.
30. Diatoma Ehrenbergii, Kg. Pilatka.
32. Stauroneis maculata, B. Enterprise.
33. Pinnularia Couperii, B.
34, 35. Zygoceros (Denticella ?) mobilensis, B.
36. Surirella circumsuta, B.
37. Scale for all the figures on this Plate, being $\frac{5}{1000}$ths of an inch, magnified equally with the drawings.

PLATE III.

Fig. 1. Biforine, from Pistia stratiotes, discharging its raphides.

2. Conochilus volvox, Ehr., without the case. Enterprise.

3. Aporea ambigua, B. See p. 42.

4, 5. Peridinium carolinianum, B. Grahamville, S. Ca.

6, 7. Philodina pannosa, B. No. 6, by the camera; No. 7, by the eye.

8, 10. Melicerta nuda, B. See p. 41. Enterprise.

11. Cothurnia maritima, Ehr. Tampa.

12. Notommata longiseta, Ehr. Enterprise.

13. Portion of arm of Stephanoceros Eichhornii? from Enterprise; showing lateral, not verticillate cilia. In other respects the American specimens agree with Ehrenberg's figures.

Fig. 9, 14. Rotifer vestitus, B. Enterprise. See p. 41, fig. 9, extended, and drawn by the eye; fig. 14, contracted, and drawn by the camera lucida.

15. Cothurnia maritima? Ehr. Tampa.

16. Acineta Lyngbyii? Ehr. St. Augustine.

17. Brachionus urceolaris, Ehr. St. Augustine.

18. Cothurnia havniensis, Ehr. Tampa.

19. Pterodina magna, B. Anastasia Island, Fa. This is drawn to the scale of fig. 25.

20, 21. Brachionus polyacanthus, Ehr. Enterprise, Fa.

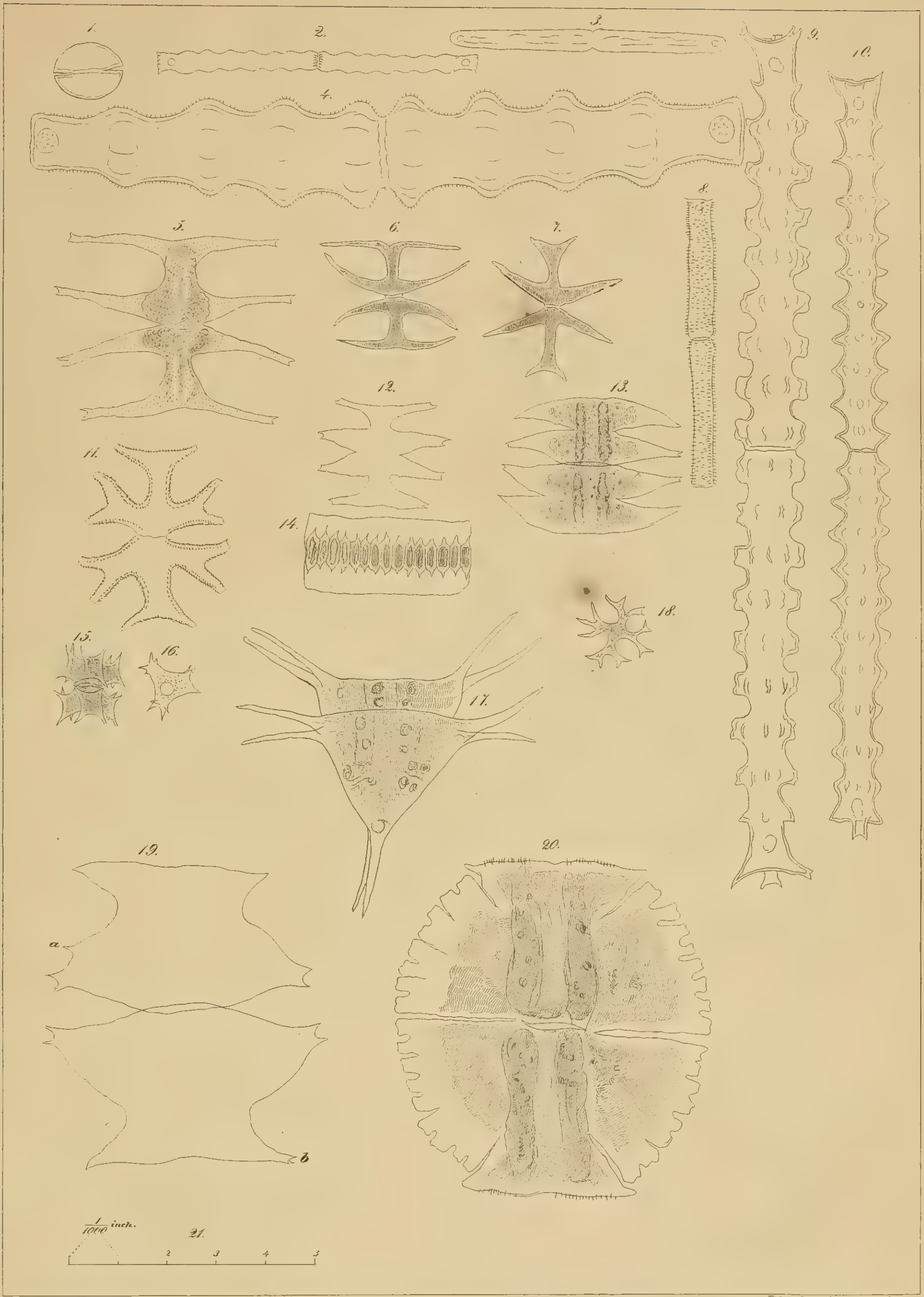
22. Acineta mystacina. Pilatka.

23. Cothurnia imberbis, Ehr. Pilatka.

24. Scale A, for figs. 1, 3, 4, 5, 11, 12, 17, and 21, being $\frac{5}{1000}$ths of an inch, magnified equally with these figures.

25. Scale B, for figs. 2, 6, 7, 8, 9, 10, 14, 15, 16, 19, and 23, being $\frac{5}{1000}$ths of an inch, magnified equally with the drawings.

Plate 1.

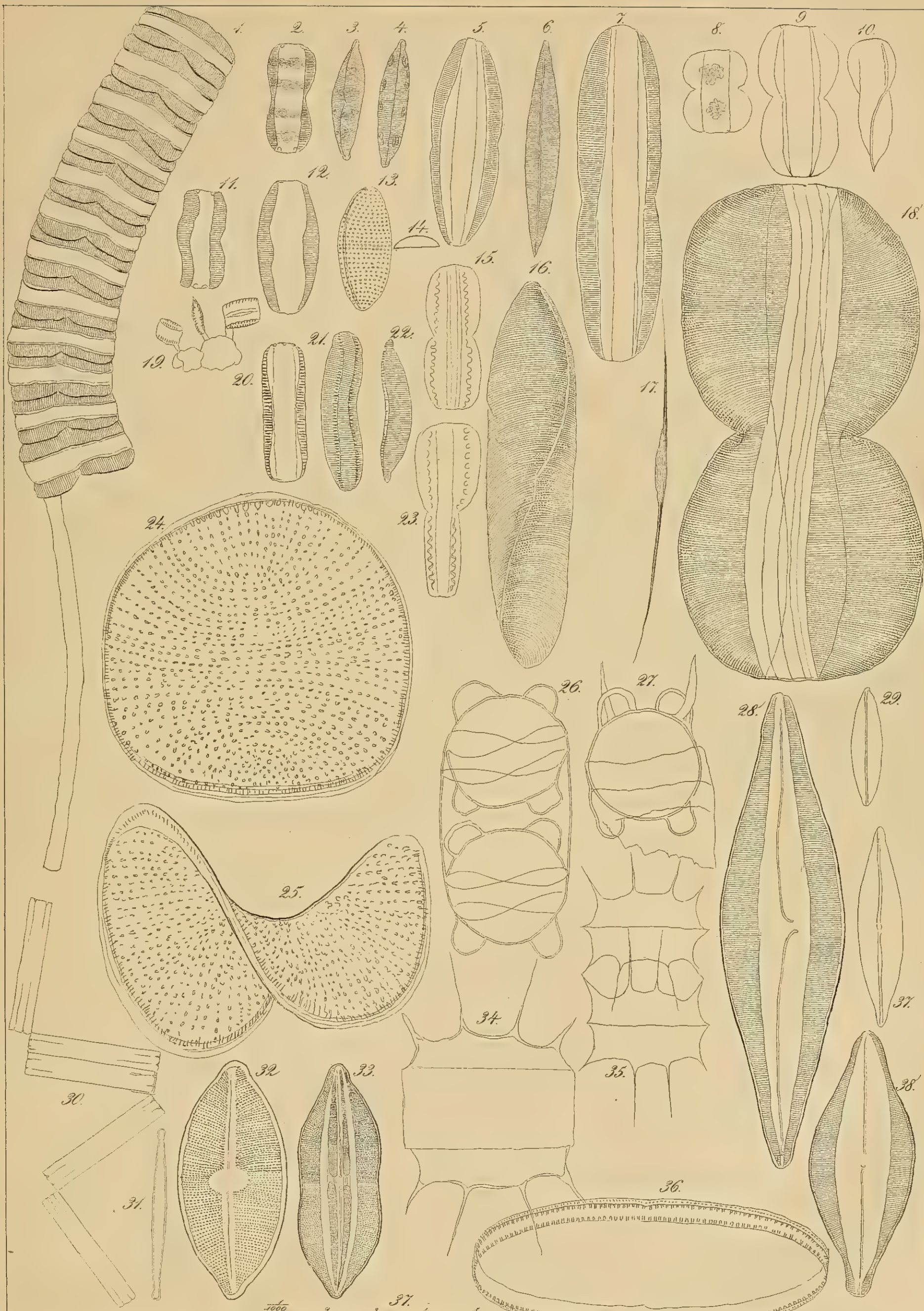


Sketched by J. W. Bailey

Lith. of Sarony & Major, N. Y.

DESMIDIEÆ.

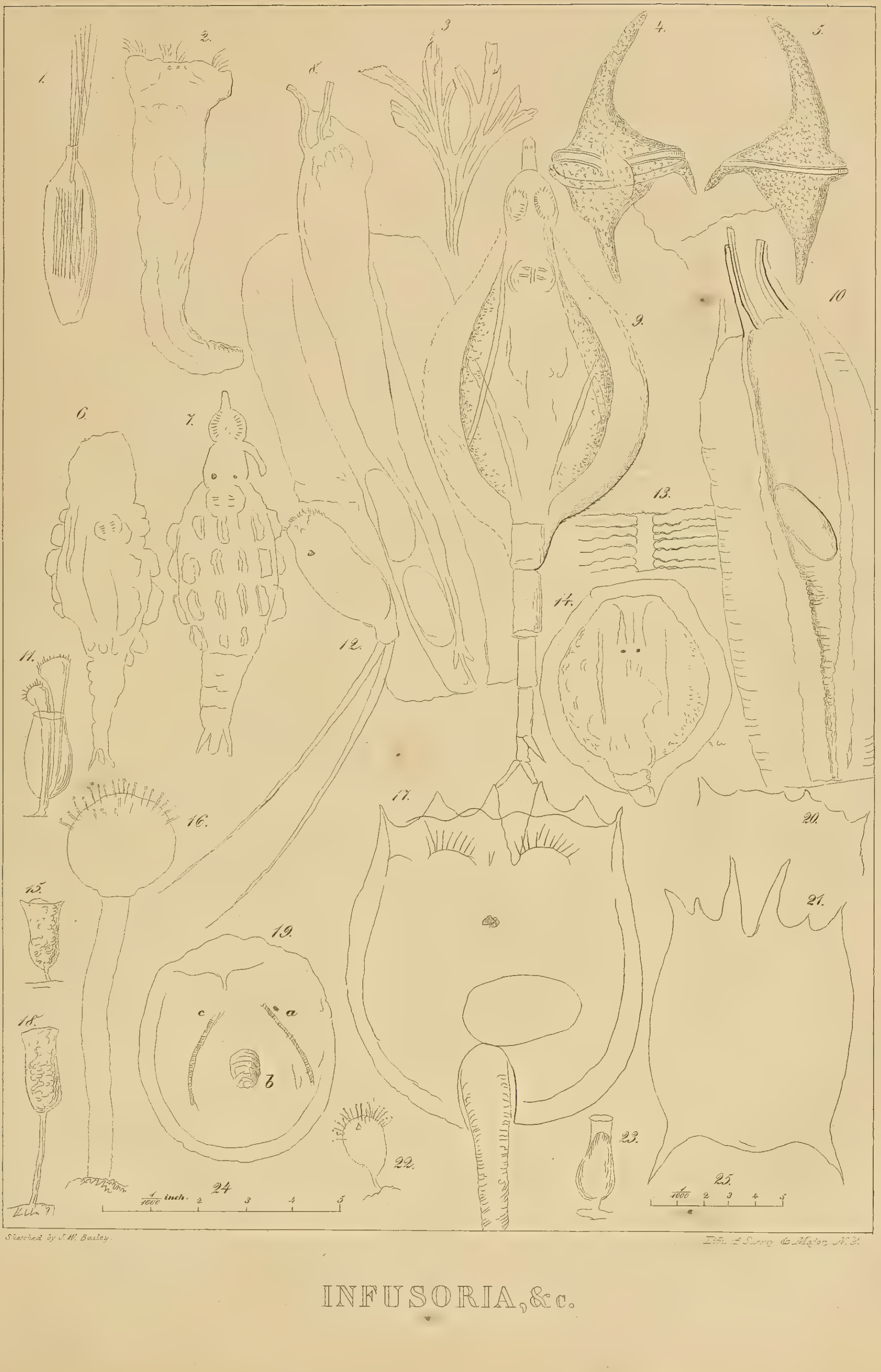
Plate 2.



Sketched by J. W. Bailey. Lith. of Sarony & Major, N. Y.

DIATOMACEÆ.

Plate 3.



INFUSORIA, &c.

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

ABORIGINAL MONUMENTS

OF

THE STATE OF NEW-YORK.

COMPRISING THE RESULTS OF

ORIGINAL SURVEYS AND EXPLORATIONS;

WITH AN ILLUSTRATIVE APPENDIX,

BY

E. G. SQUIER, A.M.

FOREIGN MEMBER OF THE BRITISH ARCHÆOLOGICAL ASSOCIATION; MEMBER OF THE AMERICAN ETHNOLOGICAL SOCIETY; THE PHILADELPHIA ACADEMY OF NATURAL SCIENCES; THE NEW-YORK HISTORICAL SOCIETY; THE MASSACHHUSETTS HISTORICAL SOCIETY; THE HISTORICAL AND ANTIQUARIAN SOCIETY OF TENNESSEE, ETC., ETC.

ACCEPTED FOR PUBLICATION

BY THE SMITHSONIAN INSTITUTION,

OCTOBER 20TH, 1849.

VOL. II.

COMMISSION

TO WHICH THE MEMOIR HAS BEEN REFERRED.

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JOSEPH HENRY,
Secretary of the Smithsonian Institution.

WASHINGTON, D. C.,
July, 1850.

PRINTED BY EDWARD O. JENKINS,
114 Nassau street, New York.

CONTENTS.

APPENDIX.

ABORIGINAL MONUMENTS

OF THE

STATE OF NEW YORK.

CHAPTER I.

INTRODUCTORY OBSERVATIONS.

The Indian tribes found in possession of the country now embraced within the limits of New England and the Middle States have left few monuments to attest their former presence. The fragile structures which they erected for protection and defence have long ago crumbled to the earth; and the sites of their ancient towns and villages are indicated only by the ashes of their long-extinguished fires, and by the few rude relics which the plough of the invader exposes to his curious gaze. Their cemeteries, marked in very rare instances by enduring monuments, are now undistinguishable, except where the hand of modern improvement encroaches upon the sanctity of the grave. The forest-trees, upon the smooth bark of which the Indian hunter commemorated his exploits in war, or success in the chase—the first rude efforts towards a written language—have withered in the lapse of time, or fallen beneath the inexorable axe. The rock upon which the same primitive historian laboriously wrought out his rude, but to him significant picture, alone resists the corrosion of years. Perhaps no people equally numerous have passed away without leaving more decided memorials of their former existence. Excepting the significant names of their sonorous language, which still attach to our mountains, lakes, and streams, little remains to recall the memory of the departed race.

But notwithstanding the almost entire absence of monuments of art clearly referable to the Indian tribes discovered in the actual possession of the region above indicated, it has long been known that many evidences of ancient labor and skill are to be found in the western parts of New York and Pennsylvania, upon the upper tributaries of the Ohio, and along the shores of Lakes Erie and Ontario. Here we find a series of ancient earth-works, entrenched hills, and occasional mounds, or tumuli, concerning which history is mute, and the origin of which has been regarded as involved in impenetrable mystery. These remains became a

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subject of frequent remark, as the tide of emigration flowed westward; and various detached notices of their existence were, from time to time, made public. No connected view of their extent or character was, however, given to the world, until 1817, when De Witt Clinton, whose energetic mind neglected no department of inquiry, read a brief memoir upon the subject before the "Literary and Philosophical Society of New York," which was published in pamphlet form, at Albany, in 1818. Mr. Clinton in this memoir did not profess to give a complete view of the matter; his aim being, in his own language, "to awaken the public mind to a subject of great importance, before the means of investigation were entirely lost." It consequently contains but little more than notices of such ancient earth-works, and other interesting remains of antiquity, as had at that time fallen under his notice, or of which he had received some distinct information. Its publication was, however, without any immediate effect; for few individuals, at that period, felt the interest requisite, or possessed the opportunities necessary, to the continuance of the investigations thus worthily commenced. Nothing further, it is believed, appeared upon the subject, until the publication of McCauley's History of New York, in 1828. This work contained a chapter upon the antiquities of the State, embodying the essential parts of Mr. Clinton's memoir, together with some facts of considerable interest, which had fallen under the observation of the author himself. Within a few years, public attention has again been directed to the subject by Mr. Schoolcraft, in his "Notes on the Iroquois." Some detached facts have also been presented in local histories and publications, but usually in so loose and vague a manner as to be of little value for purposes of comparison and research.

The observations of all these authorities were merely incidental, and were limited in their range. By none were presented plans, from actual surveys, of any of the ancient works of the State; a deficiency which, it is evident, could not be supplied by descriptions, however full and accurate, and without which it has been found impossible to institute the comparisons requisite to correct conclusions as to the date, origin, and probable connections of these remains. It has all along been represented that some of the enclosures were of regular outlines, true circles and ellipses and accurate squares—features which would imply a common origin with the vast system of ancient earth-works of the Mississippi Valley. Submitted to the test of actual survey, I have found that the works which were esteemed entirely regular are the very reverse, and that the builders, instead of constructing them upon geometrical principles, regulated their forms entirely by the nature of the ground upon which they were built. And I may here mention, that none of the ancient works of this State, of which traces remain displaying any considerable degree of regularity, can lay claim to high antiquity. All of them may be referred, with certainty, to the period succeeding the commencement of European intercourse.

Mr. Clinton was unable to learn of the occurrence of any remains upon the first terrace back from the lakes, and, upon the basis of the assumed fact of their nonexistence, advanced the opinion that the subsidence of the lakes and the formation of this terrace had taken place since these works were erected—a chronological period which I shall not attempt to measure by years. This deduction has been

received, I believe, by every succeeding writer upon the subject of our antiquities, without any attempt to verify the assumption upon which it rests. I have, however, found that the works occur indiscriminately upon the first and upon the superior terraces, as also upon the islands of the lakes and rivers.

Misled by statements which no opportunity was afforded of verifying, I have elsewhere, though in a guarded manner, ventured the opinion that the ancient remains of western New York belonged to the same system with those of Ohio and the West generally. Under this hypothesis, the question whether they were the weaker efforts of a colony, starting from the southwestern centres, or the ruder beginnings of a people just emerging from a nomadic state, becoming fixed in their habits, and subsequently migrating southward, next suggested itself; and I gladly availed myself of the joint liberality of the Smithsonian Institution and the Historical Society of New York, to undertake its investigation. The results of my observations are briefly presented in the following pages. These observations extended from the county of St. Lawrence on the north, to Chautauque on the south, embracing the counties of Jefferson, Oswego, Onondaga, Oneida, Cayuga, Seneca, Ontario, Wayne, Monroe, Livingston, Orleans, Niagara, Erie, Genesee, and Wyoming. Throughout this entire region ancient remains are found in considerable abundance ; they are also occasionally found in the counties adjoining those above named, upon the principal tributaries of the Delaware, Susquehanna, and Alleghany. They are known to extend down the Susquehanna, as far as the valley of the Wyoming ; and a single one was discovered as far east as Montgomery county, in the neighborhood of Fort Plain. Some, it is said, are to be found in Canada ; but no definite information was received of their localities. It is to be observed that they are most numerous in sections remarkable for their fertility of soil, their proximity to favorable hunting and fishing grounds—in short, possessing the greatest number of requisites to easy subsistence. They are particularly numerous in Jefferson county, in the vicinity of the central lakes, in the southern part of Monroe, in Livingston, Genesee, and Erie counties. Many are said to exist in Chautauque ; but the lateness of the season, and the unsuspected number of remains elsewhere claiming attention, prevented me from examining them.

In respect to the number of these remains, some estimate may be formed from the fact that, in Jefferson county alone, *fifteen* enclosures were found, sufficiently well preserved to admit of being traced throughout. This is exclusive of those (probably a greater number) which have been wholly or in part destroyed, or of which no information could be obtained, in the limited time allotted to the investigation of that county. It is safe to estimate the whole number which originally existed here at between thirty and forty—a greater number than was before known to exist in the State. Erie county probably contained nearly as many. In the short period of eight weeks devoted to the search, I was enabled to ascertain the localities of not less than one hundred ancient works, and to visit and make surveys of half that number. From the facts which have fallen under my notice, I feel warranted in estimating the number which originally existed in the State at from two hundred to two hundred and fifty. Probably one half of these have been

obliterated by the plough, or so much encroached upon as to be no longer satisfactorily traced.

Were these works of the general large dimensions of those of the Western States, their numbers would be a just ground of astonishment. They are, however, for the most part, comparatively small, varying from one to four acres,—the largest not exceeding sixteen acres in area. The embankments, too, are slight, and the ditches shallow; the former seldom more than four feet in height, and the latter of corresponding proportions. The work most distinctly marked exists in the town of Oakfield, Genesee county; it measures, in some places, between seven and eight feet from the bottom of the ditch to the top of the wall. In some cases the embankment is not more than a foot in height, and the trench of the same depth. Lest it should be doubted whether works so slight can be satisfactorily traced, it may be observed, that a regular and continuous elevation of six inches may always be followed without difficulty.

In respect of position, a very great uniformity is to be observed throughout. Most occupy high and commanding sites near the bluff edges of the broad terraces by which the country rises from the level of the lakes. From the brows of the limestone ledges, where some of these works occur, in Jefferson and Erie counties, most extensive prospects may be obtained, often terminating in the blue belt of the lakes, distant from ten to forty miles; the intervening country presenting a beautiful variety of cleared and forest lands, dotted with houses, churches, and villages. When found upon lower grounds, it is usually upon some dry knoll or little hill, or where banks of streams serve to lend security to the position. A few have been found upon slight elevations in the midst of swamps, where dense forests and almost impassable marshes protected them from discovery and attack. In nearly all cases they are placed in close proximity to some unfailing supply of water, near copious springs or running streams. Gateways, opening toward these, are always to be observed, and in some cases guarded passages are also visible. These circumstances, in connection with others not less unequivocal, indicate, with great precision, the purposes for which these structures were erected.

It has already been mentioned that Messrs. Clinton, Yates, and Moulton, and others, have concluded, upon the assumption that none of these works occur upon the first and second terraces above the lakes, that the latter have subsided to their present level since their erection. This conclusion does not necessarily follow from the premises. Few positions susceptible of defence, under the system practised by all rude people, are to be found upon either of these terraces; the builders, consequently, availed themselves of the numerous headlands and other defensible positions which border the supposed ancient shores of the lakes, simply because they afforded the most effectual protection, with the least expenditure of labor.

I found an entire uniformity in the indications of occupancy, and in the character of the remains of art discovered within these enclosures, throughout the whole range of their occurrence. The first feature which attracts notice, upon entering them, is a number of pits or excavations in the earth, usually at the points which are most elevated and dry. These pits are occasionally of considerable size, and are popularly called "wells," although nothing is more obvious than that they

never could have been designed for any such purpose. They are usually from three to four, but sometimes from six to eight feet in depth, and of proportionate size at the top. Their purposes become sufficiently evident upon excavation. They were the *caches* in which the former occupants of these works deposited their stores. Parched corn, now completely carbonized by long exposure, is to be discovered in considerable abundance in many of them. Instances fell under my notice where it had been found untouched to the amount of bushels, in these primitive depositories. Traces of the bark and thin slips of wood, by which the deposits were surrounded, are also frequently to be found. In many of these enclosures the sites of the ancient lodges, or cabins, are still to be traced. These are marked by considerable accumulations of decomposed and carbonaceous matter—stones much burned, charcoal and ashes mingled with the bones of animals, with numerous fragments of pottery, broken pipes, and occasionally rude ornaments, such as beads of stone, bone, and shell. The pottery, I may observe incidentally, is of very good material, and appears to have been worked and ornamented with considerable taste and skill. It is found in great abundance; and, in many of the enclosures now under cultivation, bushels of fragments might, if desirable, be collected without difficulty. The material, in common with that of all the aboriginal pottery of the North, is composed of clay tempered (if I may use the term) with pounded quartz and shells, or with fine sand, so as to prevent shrinkage, and resist the action of fire. Most of it is well burned, but none exhibits any appearance of glazing. The pipes are mostly composed of clay, regularly and often fancifully moulded, and ornamented in various ways. Some bear the form of animals, the distinctive features of which are well preserved; others are moulded in the shape of the human head, or are variously fluted and dotted with regular figures. They are generally of very good material, the clay of fine quality, and well burned. Some, indeed, are so hard, smooth, and symmetrical, as almost to induce doubts of their aboriginal origin. Some of the terra cottas, other than pipes, are really very creditable specimens of art, and compare favorably with any of the productions of the aborigines which have fallen under my notice. They are, with few exceptions, representations of animals; with the minutest features, as well as the peculiar habits of which, the American Indians had, from long observation, a thorough acquaintance.

CHAPTER II.

EARTH-WORKS, ENCLOSURES, ETC.

For the sake of convenience and easy reference, the enclosures of earth are arranged according to counties, and so described. Works which were constructed of palisades simply, without embankments or ditches, do not fall within this arrangement, but will be described collectively in a separate chapter, under the head of "Palisaded Enclosures."

ST. LAWRENCE COUNTY.

A FEW aboriginal monuments are said to have existed in this county. One or two of these occurred near Pottsdam; but it is probable they are now nearly, if not quite, obliterated.

A mound, eight feet in height, still exists on St. Regis Island, in the St. Lawrence River. It is crossed by the boundary line separating the territories of the United States and Great Britain. It was excavated by Col. Hawkins, of the United States Boundary Commission, in 1818. Near the surface were human bones in considerable numbers, and in good preservation; but at the base were found traces of fire, charcoal, burned bones, and fragments of pottery, together with some stone implements and ornaments.

Upon the Canada shore of the St. Lawrence River, opposite Morrisville in this county, a singular aboriginal deposit was discovered some years ago, in making the excavations for the St. Lawrence Canal. The principal facts concerning them were communicated to the author by Dr. T. Reynolds, of Brockville, C. W., and are embodied in Vol. I. of the "Smithsonian Contributions to Knowledge," pp. 201, 202. Amongst the relics of copper and other materials discovered at this spot and described as above, was a small *terra cotta* mask of very good workmanship. An engraving of the size of the original is herewith presented (Fig. 1). Mr. Reynolds, who has the relic in his possession, describes it as follows: "It is of clay, and represents the contour of the Indian head, after which it appears to have been moulded. It corresponds very nearly in shape with the skulls discovered at the same place, and the *foramina*, or holes found in the skull, are well represented,—showing that it was modelled to resemble the bony structure of the head, not the flesh or living subject. It seems to have been broken off from some idol or image."

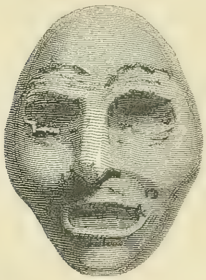

FIG. 1.

JEFFERSON COUNTY.

This county is bounded on one side by Lake Ontario, and upon the other by the wild, mountainous region which separates the waters of the Hudson River from those of the St. Lawrence. It is intersected by the Black River, one of the most picturesque streams of the State. Its surface is diversified: for about ten miles back from the shores of the lake, it is nearly level; we then reach the ledges of the Trenton limestone, and the entire country becomes more elevated and irregular. These natural features, implying an abundance of fish and game, joined to great fertility of soil and easy cultivation, fitted this county for sustaining a large aboriginal population. We are not surprised, therefore, at finding here numerous traces of former occupancy. These consist chiefly of enclosures of irregular outlines, situated, for the most part, upon the borders of the high table-land or terrace formed by the abrupt termination of the great limestone deposit of the Trenton group, the base of which, it is supposed, was formerly washed by the waters of Lake Ontario. Quite a number of these works, however, occur upon the lower terrace, in places where the natural features of the ground were favorable to their construction and objects. Works were examined in this county, in the townships of Watertown, Le Ray, Rutland, Rodman, Adams, and Ellisburgh.

The following examples are presented in the order in which they were surveyed.

PLATE I.

ANCIENT WORK, ADAMS TOWNSHIP, JEFFERSON COUNTY, NEW YORK.

This work occupies a commanding position upon the brow of the second terrace, which is here some hundreds of feet in height, and very abrupt. The ground immediately back of the site of the work is considerably depressed and swampy. It is drained by a little stream (*a*), which, falling over the cliff, forms a small but picturesque cascade. The narrow channel of this stream was formerly obstructed by a beaver-dam, which converted the marsh into a deep and impassable pond. The elevation upon which this work is situated, it will thus be seen, was well fitted by nature for defensive purposes,—possessing the two primary requisites, difficult approach and an unfailing supply of water.

The artificial defences consist of an embankment of earth, with an exterior

ditch. The forest covers the greater part of the work, and here the lines are still well preserved. The embankment has an average height of perhaps three feet, by ten feet in width at the base; the ditch is of corresponding dimensions. There are not less than seven gateways, varying from eight to thirty feet in width. Upon the right of the work, towards the swamp already mentioned, there is an abrupt bank not far from thirty feet in height, where the defences are interrupted. At the point indicated by the letter *b*, a large bass-wood (linden) tree is standing upon the embankment. It measures twelve feet in circumference, three feet above the ground. The trees within the enclosure are of the usual size.

Upon the northeastern slope of the eminence, within the walls of the enclosure, and where the soil is sandy and dry, are a great number of small pits and depressions in the earth. They are now nearly filled by accumulations of leaves, but they must at first have been from four to six feet in depth. Upon excavating some of them, it was found that they were the *caches* in which the former occupants of the work had placed their stores.* And although it seems probable the original deposits had been removed, considerable quantities of parched corn, now carbonized by long exposure, were still to be found within them. There were, perhaps, forty or fifty of these excavations within the walls, and several upon the crown of the eminence at *c*.

Upon removing the leaves at various points within the work, carbonaceous accumulations, bones of animals, fragments of pottery, and other evidences of occupation were discovered. A small portion of the work, indicated on the map, has been cleared and put under cultivation. Here, just exterior to the wall, upon the brow of the natural bank, at the spot marked *d*, several skeletons have been exhumed by the plough. They had been buried in a sitting posture, and were very well preserved.

By the operation of diluvial causes, the drift has been deposited, in a very singu-

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* The term *cache*, literally *a hide* or place of concealment, is of French origin, and has become current amongst all the traders and trappers on the frontiers. The practice of *caching* or hiding goods or provisions on outward marches, to be used upon returning, or by parties following, was derived from the Indians, among whom it was general. A *cache* is made by digging a hole in the ground, which is lined with sticks, grass, or any material which will protect the contents from the dampness of the earth. After the goods or provisions have been deposited, the earth is carefully covered over, so as to best prevent the penetration of water from above. "It is often, in fact always necessary, at the West, to leave no signs by means of which rival parties or the cunning savages may discover the place of deposit. To this end the excavated earth is carried to a distance, and carefully concealed, or thrown into a stream, if one is near. The place selected is usually some rolling point, sufficiently elevated to be secure from inundations. If it be well set with grass, a solid piece of the turf of the size of the proposed excavation is cut out. It is afterwards laid back, and taking root in a short time, no signs remain of its ever having been molested. However, as every locality does not afford a turfy spot, the camp-fire is sometimes built upon the place, or the animals are penned over it, which effectually destroys all trace of the disturbance."—(*Gregg's Commerce of the Prairies*, vol. i. p. 69.) Father Hennepin, in his account of his passage down the Mississippi River, in 1680, describes an operation of this kind in the following terms: "We took up the green sod, and laid it by, and digged a hole in the earth, where we put our goods, and covered them with pieces of timber and earth, and then put in again the green turf: so that it was impossible to suspect that any hole had been digged under it, for we flung the earth into the river."

lar manner, upon the table-land upon which the above work is situated. In some places it occurs in long, narrow ridges, conforming to the general course of the terrace bank; in others it forms amphitheatres of various sizes; and in a few instances it assumes a conical shape, resembling artificial tumuli. A short distance to the right of the work under notice is a small natural amphitheatre, rising in the midst of the marshy grounds, which has been supposed by some to be artificial. Its relative position is indicated by the letter *e*.

About one and a half miles southeast of the above work, was formerly another of perhaps larger size. It occupied a high, oval-shaped hill, one side of which is very steep, while the other subsides gently to the general level. The embankment extended in a semicircular form around that part of the hill not protected by nature; and, previous to the cultivation of the ground, was upwards of six feet in height from the bottom of the trench. A very slight depression, and the greater luxuriance of the verdure, resulting from the filling of the trench with surface loam, are all that now indicate the original lines. It is said that there was an avenue leading off, for some distance, to the westward; but it is no longer traceable. At the base of this hill is a boulder, in which are several artificial depressions, doubtless intended for mortars, and a variety of grooves, in which the stone axes and other implements of the aborigines were rubbed, in order to reduce them to the required shape.

PLATE II. No. 1.

ANCIENT WORK ON "DRY HILL," FIVE MILES SOUTHEAST OF WATERTOWN, JEFFERSON COUNTY, NEW YORK.

Following the brow of the terrace northward from the work first described, for about two miles, we come to another work of somewhat more regular figure, and of larger dimensions. Most of it is under cultivation, and the outlines are very much defaced. The embankment, upon one side, runs into the forest land, where it is well preserved, measuring, perhaps, three feet in height. The darker lines of the engraving show what parts are still distinctly marked; the dotted lines those which have been ploughed down, and which are no longer distinguishable from the general level, except by the deeper green and more luxuriant growth of the grass on the line of the ancient trench. The position of the work, it will be seen, corresponds very nearly with that of the one previously described. There is, however,

no water near at hand, except a limited supply from a small spring. Nevertheless, this seems to have been the site of a very populous aboriginal town. The entire area of the work is covered with accumulations of carbonaceous matter, burned stones, fragments of bones, pottery, etc. Indeed, these indications are visible for some distance exterior to the walls, upon the adjacent level. These artificial accumulations have rendered the soil within the enclosure extremely fertile, and it sustains most luxuriant crops. In cultivating the area, many fragments of human bones, some of them burned, have been observed,—suggesting the possibility that the ancient village was destroyed by enemies, and that these are the bones of its occupants, who fell in defence of their kindred, and were burned in the fires which consumed their lodges. A little to the northward of the work, there seems to have been an aboriginal cemetery. Here the plough frequently exposes skeletons, buried according to the Indian mode, and accompanied by various rude relics of stone and bone. Within and around the work are also found stone axes, flint arrow-heads, and other remnants of savage art. Fragments of pottery and broken pipes of clay are, however, most abundant. Of these bushels might be collected without much difficulty.

It is clear that this work was not intended as a place of last resort, but was occupied by a considerable population for a long period. It was undoubtedly a fortified town. It should be remarked, that although now nearly or quite filled up, here were originally a number of pits (popularly known as *wells*) of considerable size, the *caches* of the ancient occupants.

PLATE II. No. 2.

ANCIENT WORK TWO AND A HALF MILES SOUTHEAST OF WATERTOWN, JEFFERSON COUNTY, NEW YORK.

Still continuing along the brow of the terrace northward, for two and a half or three miles, we reach a third work, the greater part of which is covered with forest, and is consequently well preserved. It is much smaller than any of those before described, and is bounded by a series of right lines, slightly rounded at the angles, which gives it something of the appearance of a modern field-work. The slope of the terrace bank is here comparatively gentle, and there is a *step* or table about midway from the brow to the base. Here a number of springs start out, below the stratum of rock. Formerly the walls of the work were continued down the slope, towards the springs, as indicated by the dotted lines in the plan. They are not now to be traced further than the edge of the terrace. The position of this work is remarkably fine, and was selected with taste and skill. The table-land immediately around it is level; the soil gravelly and dry. There seems to have

been a burial-place in this vicinity, and pipes and fragments of pottery are of common occurrence. It is to be hoped that the remaining portion of this work will be preserved from the encroachments of the plough.

PLATE III. No. 1.

ANCIENT WORK HALF A MILE WEST OF BURRVILLE, NEAR WATERTOWN, JEFFERSON COUNTY, NEW YORK.

A WORK, differing somewhat from those before described, is situated two miles north of the enclosure last noticed, upon a high promontory or headland, half a mile west of the little village of Burrville. The northern base of this promontory is washed by a small and rapid stream, a branch of the east fork of Sandy Creek. Deep ravines lend strength to the position on the remaining sides, except towards the west, where it joins the highlands. Here, extending across the neck of the promontory, (the only direction from which access is easy,) was formerly an artificial defence, consisting of an embankment of earth and a trench. The plough has filled the one and levelled the other, but the lines can still be accurately traced by attending to the various circumstances already repeatedly mentioned. At the part marked *a*, was formerly a large deep pit, resembling the cellar of a dwelling-house. At *b*, was also an accumulation of large stones, bearing traces of fire; and which the early settlers, indulging in vague notions of the mineral wealth of the country, called "*the Furnace.*"

Most of these stones were used to fill the pit near by; but enough still remain to mark the site of the supposed "furnace." Whenever the land of this work is ploughed over, many relics of art are disclosed, fragments of pottery, broken pipes, implements of stone and bone, beads of similar materials, etc., etc.

About a mile northeast of this place, upon a fine level tract of ground, are the traces of an aboriginal village. Rude fireplaces, constructed of rough stones huddled together, and surrounded by carbonaceous accumulations, sometimes two feet deep, mark the site of the ancient lodges. These indications are numerous. Here, too, are to be found relics, entirely corresponding with those already noticed, as occurring within and around the ancient enclosures.

PLATE III. No. 2.

ANCIENT WORK, RUTLAND TOWNSHIP, JEFFERSON COUNTY, NEW YORK.

The slightest and much the rudest structure discovered in Jefferson county, is the one here delineated. It is situated about a hundred rods back from the brow of the terrace, already so often referred to, and which here rises abruptly from the inferior level, presenting a bold, and in some places, a precipitous bank.

Notwithstanding its elevation, this terrace has numberless depressions or basins, which are wet and marshy. Upon a slight elevation, in the midst of one of these, and still covered with a primitive forest, is the work in question. It will be observed that it is exceedingly irregular, and that the lines are interrupted by several wide openings, which are quite too broad to be regarded as gateways.

The embankment is not of uniform dimensions. In some places it is elevated but a foot or eighteen inches, by four or five feet base, while in others it is perhaps three feet in height. The ditch is also irregular,—in sections scarcely exceeding a large plough furrow in depth and width. In fact, the work seems imperfect, and to have been constructed in haste for temporary purposes. Within the area, which is quite uneven, are several small accumulations of stones, which bear the marks of fire. Upon removing some of them, the proprietor of the ground found ashes and other burnt matter, amongst which was a carbonized ear of maize. A small but entire vessel of pottery, of considerable symmetry of shape, was also found here some years since.

Human bones have been discovered beneath the leaves; and in nearly every part of the trench skeletons of adults of both sexes, of children, and infants, have been found, covered only by the vegetable accumulations. They seem to have been thrown together promiscuously. They have also been found in a narrow depression resembling an artificial trench, indicated by a dotted line in the plan, and caused by the subsidence of the earth in a cleft of the limestone substratum. These skeletons, from all accounts, do not seem to have been much decayed, and no difficulty was experienced in recovering them entire. The skulls were in some cases fractured, as if by a blow from a hatchet or club. These circumstances would seem to imply, not only that the work is of comparatively late construction, but also that this was the scene of one of those indiscriminate massacres so common in the history of savage warfare.

From the bank of the terrace, near this work, a very extensive and beautiful prospect is commanded.

PLATE III. No. 3.

ANCIENT WORK HALF A MILE WEST OF LOCKPORT, JEFFERSON COUNTY, NEW YORK.

The remaining works of Jefferson county, so far as investigated, are situated on lower grounds, generally near streams, which are made subservient to art for purposes of defence. The work here presented is a good example. It is situated on Black River (*Kā-me-hārgo*), in Le Ray township, half a mile below the little manufacturing town of Lockport. The banks of the river are here very high, and quite inaccessible. The character of the work is well shown in the engraving, and needs little explanation beyond what that affords. It will be seen that the ends of the embankment extend for a short distance down the slope of the river bank, and then curve slightly inwards, as though designed to prevent the flanks being turned by an enemy. The lines, where they cross the road, and between the road and the river, are very distinct, and the embankment is between three and four feet in height. The rest of the work may be traced without much difficulty, although it has long been under cultivation. Upon the wall, at the point indicated by the letter *c*, is still standing a pine stump, upwards of three feet in diameter, probably having an age of not less than four hundred years. The usual relics are found within the area of the enclosure; and in the natural bank at *d*, a number of skeletons have been disclosed by the plough. They are much decayed, but in respect of position correspond with those found elsewhere in Indian cemeteries.

PLATE IV. No. 1.

ANCIENT WORK, LE RAY TOWNSHIP, SIX MILES NORTHEAST OF WATERTOWN.

In the same township with the foregoing work, and about four miles distant, in a northwest direction, is the work here represented. It occupies a small sandy elevation, situated in the midst of low grounds. It is lozenge-shaped, and is the most regular of any ancient structure which has fallen under notice of the author in the State. Where the lines are intercepted on the north, the ground is considerably elevated, and subsides abruptly, precluding the necessity of an embankment for defensive purposes. The sites of the ancient lodges, indicated by heaps of burned stones, calcined shells, fragments of pottery, etc., are yet to be traced, notwithstanding that the land has been for a considerable time under cultivation. Near this work skeletons have been frequently exhumed.

PLATE IV. No. 2.

ANCIENT WORK, LE RAY TOWNSHIP, JEFFERSON COUNTY, NEW YORK.

Three miles to the westward of the enclosure last described, near "Sandford's Corners," was formerly another work of similar character, but larger size. Only a small portion of the embankment is yet visible; the dotted lines, however, show the original outlines, according to the recollection of those who were acquainted with the work before it was disturbed. The walls then measured not less than six feet in height, measuring from the bottom of the trench.

Within the area are found great numbers of the shells of the fresh-water molluscas, accumulations of burnt matter, quantities of pottery in fragments, with broken pipes, etc. Some of the pipes are of good workmanship and fine finish. In this vicinity, also, have skeletons been found; all buried in a sitting posture.

Several other works formerly existed in this township, but they have been either entirely or in great part obliterated. One is spoken of near Felt's Mills, but no opportunity was afforded of examining it.

PLATE IV. Nos. 3 and 4.

ANCIENT WORKS IN ELLISBURGH TOWNSHIP, JEFFERSON COUNTY, NEW YORK.

A number of ancient works formerly existed in Ellisburgh, one of the southern towns of the county. Plate IV., No. 3, is one of those which are yet perfect. It presents no novel features, is protected in the usual manner, and has the usual relics and traces of occupancy within its walls. Three quarters of a mile to the eastward is another similar, but larger work (Plate IV., No. 4), which has been very nearly obliterated by the plough. The sections indicated in the engraving are yet quite distinct; nor can the parts supplied differ very materially from the original lines. Perhaps no work in the State has more decided evidences of aboriginal occupation. The entire area is covered with traces of ancient habitations, and with relics of art,—pottery, ornaments, and implements. Exterior to the walls, in all directions, but particularly on the level grounds between the two works, the same indications are abundant. Indeed, the artificial accumulations are so great as materially to augment the fertility of the soil. *Caches* have been observed here, in some of which the present proprietor of the grounds has found a number of bushels of parched corn, carbonized by long exposure. It is scattered

over the surface, and may after rains be collected in considerable quantities. Here, too, have been found skeletons buried according to the usual custom.

The aboriginal population must have been very large at this spot, which, both in aspect of soil and the close proximity of springs and pure streams, affords a most beautiful site for an Indian village.

About a mile to the southward of this group, upon the land of Mr. Mendall, was another work, of which no trace now remains. Another occurred at a place called Clark's Settlement, still another at Ellis Settlement, and others in various parts of the township, concerning which no definite information can now be obtained.

Near the neat and pretty village of Pierrepoint's Manor, is also the site of an ancient town, undistinguishable from the fortified village already described, except by the absence of an embankment and trench. Large quantities of relics have been recovered here. A work of considerable size was visible until within a few years, half or three fourths of a mile northwest of the village of Adams, on the lands of Mr. W. Benton. It is described by Mr. Justus Eddy, in a letter to the author, as having been semicircular in form, five hundred feet in diameter, and the open segment facing or rather opening towards a marshy piece of ground, through which flowed a small stream. There were two or three breaks, or passage-ways, in the embankments. At the time of the settlement of this part of the country by the whites, about fifty years ago, trees two and three feet in diameter were growing upon the wall, and within the area. The embankment was then between three and four feet in height. Within the work were found quantities of pottery, pipes, and beads, covered with ornamental figures. A silver star-shaped ornament, bearing the initials P. H., was also found. It was quite thin, not exceeding the common sixpence in thickness.

Upon an island, outside of Sackett's Harbor, known as Snow-shoe Island, it is said, there are traces of an ancient work. So far as could be gathered, it was a palisaded structure, unaccompanied by an embankment.

Besides the various earth-works above described, there are a number of other interesting objects of antiquarian interest in this county. Among them may be mentioned the "*bone-pits*," or deposits of human bones. One is found near the village of Brownsville, on Black River. It is described as a pit, ten or twelve feet square, by perhaps four feet deep, in which are promiscuously heaped together a large number of human skeletons. It will be seen ultimately, that these accumulations owe their origin to a remarkable custom, common to many of the Indian tribes, of collecting and depositing together the bones of their dead, at stated intervals. Another pit, very unlike this, however, exists about three miles east of Watertown. It is situated upon the slope of a hill, and was originally marked by a number of large stones heaped over it. Upon removing these and excavating beneath them, a pit about six feet square, and four deep, was discovered, filled with human bones, all well preserved, but in fragments. Upwards of *forty* pairs of the *patella* were counted, showing that at least that number of skeletons had been deposited in the pit. It is said that the bones, when first exhumed, exhibited marks such as would result from the gnawing of wild animals; and from this circumstance, and the fact that they were so much broken up, it has been very plausibly supposed

that these are the bones of some party which had been cut off by enemies, and whose remains were subsequently collected and buried by their friends. All the bones are those of adults. Many of the fragments have been removed and scattered, but several bushels yet remain. No relics of any kind were found with them.

A large mound is said to occur "about one mile from Washingtonville, and eleven from Adams, on a cross-road from the 'ridge road,' leading from Lamb's tavern to Washingtonville. It is conical in shape, and thirty feet high." It is questionable whether this is artificial.

OSWEGO COUNTY.

A GREAT part of this county is low and wet, and it is not generally so well adapted to sustain an aboriginal population as the adjoining counties of Jefferson and Onondaga. Few ancient monuments occur within its limits; and concerning these, little was ascertained in the course of these investigations. The following facts were chiefly derived from J. V. H. Clark, Esq., of Manlius, Onondaga county, whose attention was especially called thereto in the preparation of his forthcoming History of the Onondaga and Oswego Country. Two enclosures, circular in form, existed in Granby township, in the southern part of the county. One of these occurred on State's Hundred, lot 24. Each contained about two acres, and both had gateways opening to the east. Another formerly existed near Phillipsville, of which no traces now remain; and still another is said to occur in Granby township, near "Little Utica," in a bend of Ox Creek. Near the town of Fulton, on the west side of Oswego River, is a mound of small size, which seems to be made up of human bones promiscuously heaped together. They are much decayed. Intermixed with them were found a number of flint arrow-heads. It is probable that none of these remains possessed features differing essentially from those of other parts of the State.

ONONDAGA COUNTY.

PROBABLY no county in the State had originally a greater number of aboriginal monuments within its boundaries, than the county of Onondaga. It has, however, been so long settled, and so generally brought under cultivation, that nearly all vestiges of its ancient remains have disappeared. The sites of many are, however, still remembered; but even these will soon be forgotten. It is a fortunate circumstance that the antiquities of this county were the first to attract the attention of observers, and our accounts relating to them are more complete than concerning those of the other parts of the State. Still we have to regret that we have not a single plan from actual survey,—a deficiency which no mere description can supply. Our principal source of information respecting their numbers, localities, and character, is the memoir of De Witt Clinton, already several times alluded to. Mr. Schoolcraft and Mr. J. V. H. Clark, of Manlius, have presented additional information; and from these authorities we derive most of the facts which follow.

Ancient works occurred in the towns of Fabius, De Witt, Lafayette, Camillus, Onondaga, Manlius, Elbridge, and Pompey; but of many of them we know nothing beyond the simple fact of their former existence. It should be mentioned that some of the townships here named have been erected within the last few years, and since the date of Mr. Clinton's Memoir.

Those in Elbridge, according to Mr. Clinton, occurred near the village of that name, about four miles from Seneca River, upon lands then (1817) occupied by Judge Munro. They were two in number. "One was on a very high hill, and covered three acres. It had a gateway opening towards the east; and upon the west was another, communicating with a spring about ten rods from the fort. It was elliptical in shape: the ditch deep, and the eastern wall eight feet high. The stump of a black oak-tree, certainly one hundred years old, stood upon the embankment. The second work was about half a mile distant, upon lower grounds. It was constructed like the first, but was only half as large. * * * * The early settlers observed, in this vicinity, the shells of testaceous animals accumulated, in several places, in considerable masses, together with numerous fragments of pottery. Judge Munro found, in digging the cellar of his house, several pieces of burned clay; and, in various places, large spots of deep black mould, demonstrating the former existence of buildings or erections of some kind. At one place he observed what appeared to be a well, viz., a hole ten feet deep, and the earth much caved in. Upon digging to the depth of three and a half feet, he came to a quantity of flints, below which he found a great number of human bones." This dispo-

sition of the dead, Mr. Clinton conjectures, was made by an enemy; but we shall soon see that it probably owed its existence to the practice of gathering the bones of the dead at stated intervals, and depositing them in pits,—a practice common among the Hurons and other Indians around the great lakes.

"In the town of Pompey," continues Mr. Clinton, "is the highest ground in that county, which separates the waters flowing into the Chesapeake and the Gulf of St. Lawrence. The most elevated portions of the town exhibit the remains of ancient settlements, and in various places the traces of a numerous population appear. About two miles south from Manlius Square, in this township, I examined the remains of a large town, which were obviously indicated by large spots of black mould, at intervals of a few paces asunder, in which I observed bones of animals, ashes, carbonized grains of corn, etc., denoting the residence of human beings. This town must have extended at least half a mile from east to west, and three-quarters of a mile from north to south. On the east side of this old town there is a perpendicular descent of one hundred feet, into a deep ravine, through which flows a fine stream of water. Upon the north side is a similar ravine. Here there are graves, on each side of the ravine, close to the precipice. Some of the graves contain five or six skeletons, promiscuously thrown together. On the south bank of the ravine, gun-barrels, bullets, pieces of lead, and a skull perforated by a bullet have been found. Indeed, relics of this kind are scattered all over these grounds. A mile to the eastward of this town, there is a cemetery, containing three or four acres; and to the westward of it is still another.

"There are, in this vicinity, three old forts, placed in a triangular position, and within eight miles of each other. One is about a mile south of Jamesville [in the present town of De Witt], the second in a northeastern, and the third in a south-eastern direction. They are circular or elliptical in form; bones are found scattered over their areas; and standing on a heap of mouldering ashes, within one of them, I saw a white pine-tree, eight and a half feet in diameter, and at least one hundred and thirty years old."

Mr. Clinton expresses the opinion that the three "forts" were designed to protect the "town," the vestiges of which attracted his attention; and he even goes so far as to conjecture, from the occurrence of bones upon the brows of the northern ravine, that the attack by which the town was destroyed was made from this direction! Of course this is wholly supposititious. The relics of European art, scattered over the site, show clearly enough that this was an Indian village, occupied by the savages subsequent to the commencement of intercourse with the whites. The traces which Mr. Clinton describes are precisely those which mark the site of every abandoned Indian settlement throughout the country. This county possessed a very heavy aboriginal population; probably greater than any equal extent of territory north of the Floridas; and it is not surprising, therefore, that the traces of ancient occupancy are so abundant.* Mr. Clinton states that it was

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* Mr. Schoolcraft states, on the authority of Le Fort, late chief of the Onondagas, that Ondiaka, the great chronicler of his tribe, informed him, on his last journey to Oneida, that in ancient times, before they

estimated there were not less than eighty cemeteries in Pompey township alone. McCauley states that one of the three works, mentioned above by Mr. Clinton, was triangular in form, and contained about six acres.

Mr. J. V. H. Clark has described a work situated in part of lot 33 in this township; but whether or not it is one of the three mentioned by Mr. Clinton, it is impossible to determine. "It is about four miles southeast from Manlius village, situated on a slight eminence, which is nearly surrounded by a deep ravine, the banks of which are quite steep and somewhat rocky. The ravine is in shape somewhat like an ox-bow, made by two streams which pass nearly around and then unite. Across this isthmus of this peninsula, if we may so call it, was a wall of earth running from northeast to southwest. When first discovered by the early settlers, the embankment was straight, four or five feet high, with an exterior ditch from two to three feet deep. The area thus enclosed is from ten to twelve acres. A portion of the area was free from trees, and was called the *Prairie*, and is still noted among the old men as the spot where the first battalion military training was held in the county of Onondaga. But that portion of the work near the wall has recently been cleared of a heavy growth of black-oak timber. Many of the trees were large, and probably one hundred and fifty or two hundred years old. Some were standing in the ditch and others on the embankment. The plough has defaced the lines to a considerable degree, but they may still be traced the whole extent. Within the enclosure there is a burial-place. Here, too, are to be found numerous fragments of dark-brown pottery, of coarse material."*

Mr. Clark mentions that a great number of rude relics have been discovered here. Among other things found in the vicinity were some small three-pound cannon balls. There is a large rock in the ravine on the south, on which the following characters are inscribed, viz.: IIIIIX. They are cut nine inches long, three-quarters of an inch deep, and the same in width, and are perfectly regular.

Within two miles of Jamesville, in De Witt township, upon the banks of Butternut Creek, there existed until recently the traces of an enclosure or fort, and in the vicinity many evidences of comparatively late occupation by the Indians. The fort had been rectangular, with bastions, and constructed with cedar pickets, firmly set in the ground. The stumps of the palisades were struck by the plough when the land was first cultivated. It appeared that the cabins which it had enclosed had been arranged with regularity—a practice not common among the Indians before intercourse with the whites. In the year 1810 an oak was felled near this fort, in cutting which a leaden bullet was found imbedded in the wood. One hun-

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had fixed their settlements at Onondaga, and before the Five Nations were confederated, the Onondagas lived below Jamesville and in Pompey; that in consequence of continued warfare with other tribes, they removed their villages frequently; and that, after the confederation, their fortifications being no longer necessary, they were allowed to fall into decay. This he believed was the origin of the ancient works at these points.—*Notes on the Iroquois*, p. 442.

* Schoolcraft's Notes on the Iroquois, p. 469.

dred and forty-three cortical layers were counted above it. It must, therefore, have been fired in 1667. Fire-arms were introduced among the Iroquois, by the French, as early as 1609—the date of Hudson's exploration of the river bearing his name. Brass crucifixes, medals of silver and other metals, dial-plates, and articles of iron are of frequent occurrence here, mingled with stone-axes, and implements and ornaments of bone, shell, and clay, the relics of an earlier period. Amongst other articles of European origin, a cross of pure gold was found some years ago, bearing the sacred monogram I. H. S. Not far from this spot are two high hills of great regularity, sometimes called mounds, the surfaces of which are covered with pits, and which Mr. Schoolcraft conjectures were *caches.*

Some investigators are of opinion that Champlain penetrated into this county in 1615. The reasons in support of this opinion are forcibly put forward by Mr. O. H. Marshall, of Buffalo, in a paper published in the Bulletin of the New York Historical Society, for March, 1849. From this paper the subjoined account of the Indian fort attacked by Champlain is extracted. It throws light upon the modes of defence common to the Indians at that period, besides being of interest in several other particulars. Says Champlain:

" 'On the 10th of October, at 3 P. M., we arrived before the fort of the enemy. Some skirmishing ensued among the Indians, which frustrated our design of not discovering ourselves until the next morning. The impatience of our savages, and the desire they had of witnessing the effects of our fire-arms on the enemy, did not suffer them to wait. When I approached with my little detachment, we showed them what they had never before seen or heard. As soon as they saw us, and heard the balls whistling about their ears, they retired quietly into the fort, carrying with them their killed and wounded. We also fell back upon the main body, having five or six wounded, one of whom died.'

" The Indians now retired out of sight of the fort, and refused to listen to the advice of Champlain as to the best mode of conducting the siege. He continued to aid them with his men, and, in imitation of the more ancient mode of warfare, planned a kind of movable tower, sufficiently high when advanced to the fort to overlook the palisades. It was constructed of pieces of wood placed one upon another, and was finished in one night.

" 'The village,' says Champlain, 'was enclosed by four rows of large interlaced palisades, thirty feet high, near a body of unfailing water. Along these palisades the Iroquois had placed conductors to convey water to the outside, to extinguish fire. Galleries were constructed inside of the palisades, protected by a ball-proof parapet of wood, garnished with double pieces of wood.

" 'When the tower was finished, two hundred of the strongest men advanced it near to the palisades. I stationed four marksmen on its top, who were well protected from the stones and arrows which were discharged by the enemy.'

" The French soon drove the Iroquois from the galleries; but the undisciplined Hurons, instead of setting fire to the palisades, as directed by Champlain, consumed the time in shouting at the enemy, and discharging harmless showers of

arrows into the fort. Without discipline, and impatient of restraint, each one acted as his fancy pleased him. They placed the fire on the wrong side of the fort, so that it had no effect.

"'When the fire had gone out, they began to pile wood against the palisades, but in such small quantities that it made no impression. The confusion was so great that nothing could be heard. I called out to them, and pointed out, as well as I could, the danger they incurred by their imprudent management; but they heard nothing by reason of the great noise which they made. Perceiving that I should break my head in calling, that my remonstrances were in vain, and that there were no means of remedying the disorder, I resolved to effect, with my own people, what could be done, and to fire upon those we could discover.

"'In the meantime, the enemy profited by our disorder. They brought and threw water in such abundance, that it poured in streams from the conductors, and extinguished the fire in a very short time. They continued, without cessation, to discharge flights of arrows, which fell on us like hail. Those who were on the tower killed and wounded a great number.

"'The battle lasted about three hours. Two of our chiefs, some head-men, and about fifteen others were wounded.'"

Mr. Marshall is of the opinion that this fort was situated upon the shores of Onondaga Lake. He arrives at this conclusion from an analysis of the courses and distances travelled by Champlain, the streams which he crossed, etc., and continues:

"Another circumstance to aid us in the location, is the description given by Champlain of the fort itself. 'It was situated,' says he, 'on the borders of an unfailing body of water.' This he calls '*Etang*,' a word generally applied to an artificial pond, but sometimes used for a small lake or other natural collection of water. There is nothing that will answer the terms of the description in so many particulars, as the shore of Onondaga Lake; and it is quite probable that it is there we must look for the location of the fort which was invested by the invaders.

"Three miles southeast of its outlet, on the northern bank of the lake, and near the present village of Liverpool, an ancient Indian work was discovered by the early settlers, which may have been the site of the fortification in question. There is reason to believe that the same locality was occupied by Monsieur Dupuis and the Jesuits, when they established themselves among the Onondagas in 1656.

"Mr. Clark, of Manlius, thinks that the Count de Frontenac occupied this position when he invaded the Onondaga country, in 1696, and that Col. Van Schaick encamped there while on his expedition against the Onondagas, in 1779."

In the account of Frontenac's Expedition, contained in Vol. V. of the Paris Documents, now deposited in the office of the Secretary of State of New York, it is stated that the principal fort of the Onondagas was burned by the Indians upon the approach of the French army. The terms of the account are as follows: "The cabins of the Indians and the triple palisade which encircled their fort were found entirely burnt. It was an oblong flanked by four regular bastions. The

two rows of pickets, which touched each other, were of the thickness of an ordinary mast; and at six feet distance outside stood another palisade of much smaller dimensions, but from forty to fifty feet high." This account also states that the invaders were successful in discovering almost all of the *caches* in which the Indians had deposited their corn.*

MADISON COUNTY.

On the site of the village of Cazenova, situated in the township of the same name, which adjoins Pompey, Onondaga county, on the east, it is said an ancient earth-work once existed. No vestige of it now remains. By some it was represented to be circular, by others rectangular. Many rude relics have been found here.

In the town of Lenox there were still visible, in 1812, the traces of a work of more modern date. It occupied a position corresponding with most of the defensive structures of the aborigines, at the junction of two deep ravines, the precipitous banks of which not only afforded protection, but precluded the necessity, in great part, of artificial defences. Within the point thus cut off and defended there is a small eminence, in which there are a number of excavations, containing traces of decayed wood.

It may be suggested (though, not knowing their dimensions, the suggestion may be absurd) that the pits were originally designed for *caches*. Mr. Schoolcraft supposes that this work was erected by the French,—a supposition which finds support in the regular form of the palisaded outlines, and the circumstance that the ground within and around the work has not yet returned to a forest state.

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* Documentary History of New York, Vol. I., p. 332.

OTSEGO COUNTY.

It is stated, upon very good authority, that an ancient circular earth-work once existed near Unadilla, in this county. Nothing is known concerning it, further than that it was situated on low ground.

CHENANGO COUNTY.

There was formerly an ancient enclosure, of small size, within the limits of the village of Oxford, in the township of that name, on the banks of the Chenango River. It is described by Clinton as occupying a small eminence, three or four acres in extent, which rises abruptly from the flats bordering the river. At the base of this eminence, upon the western side, flows the stream, and here the descent is precipitous. A line of embankment and a trench extended in a semicircular form from this bank, leaving narrow interruptions at the ends, for ingress and egress. The area thus enclosed was about three-fourths of an acre. At the period of the first settlement, it was covered with a dense forest; yet, says Mr. Clinton, "the outline of the work could be distinctly traced among the trees, and the elevation from the bottom of the trench to the top of the embankment was about four feet. The stump of a decayed pine which stood upon the wall exhibited one hundred and ninety-five cortical layers, and there were many more which could not be counted, as the heart of the tree alone remained. Probably the tree was three or four hundred years old,—certainly more than two hundred. It probably stood many years after it had completed its growth, and it is reasonable to suppose that some time elapsed from the period of the construction of the work to the commencement of the growth of the tree.

"Probably the work was encircled with palisades, but no traces of the wood were discoverable. The situation was very eligible, elevated, commanding a fine prospect, and having no eminence near from which it could be commanded. No implements or utensils have been found, except some fragments of coarse pottery, roughly ornamented. The Indians have a tradition that the family of the Antones, which is supposed to belong to the Tuscarora nation, is the seventh generation from the inhabitants of this fort; but of its origin they know nothing.

"There is also a place at Norwich in this county, on a high bank of the river, called 'the Castle,' where the Indians lived at the period of our settlement of the country, and where some vestiges of a fortification appear, but in all probability of much more modern date than those at Oxford."

In Greene township, about two miles below the village, was formerly a mound of some interest. It was situated about thirty rods back from the bank of the Chenango River, and was originally about six feet in height and forty in diameter. "Until within a few years a large pine stump stood on its top, and a variety of trees covered it when first discovered. One of these showed two hundred consecutive growths. An examination of the mound was made in 1829 by excavation. Great numbers of human bones were found; and beneath them, at a greater depth, others were found which had evidently been burned. No conjecture could be formed of the number of bodies deposited here. The skeletons were found lying without order, and so much decayed as to crumble on exposure. At one point in the mound a large number, perhaps two hundred, arrow-heads were discovered, collected in a heap. They were of the usual form, and of yellow or black flint. Another pile, of sixty or more, was found in another place, in the same mound; also a silver band or ring, about two inches in diameter, wide but thin, and with what appeared to be the remains of a reed pipe within it. A number of stone gouges or chisels, of different shapes, and a piece of mica, cut in the form of a heart, the border much decayed and the laminæ separated, were also discovered."*

It may be mentioned here, that the character of the lower deposit, and also some of the relics, coincide with some of those found in the mounds of the Mississippi Valley. The ancient mound-builders often burned their dead. The upper and principal collection of bones had probably a comparatively late date, as is shown by the silver bracelet, which, it is presumed, although not so expressly stated, was found with this deposit.

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* Annals of Binghampton.

CAYUGA COUNTY.

PLATE V. No. 1.

ANCIENT WORK NEAR AUBURN, NEW YORK.

One of the best preserved and most interesting works in the State, is that overlooking the flourishing town of Auburn. It is situated upon a commanding eminence, which rises abruptly from the level grounds upon which the town is built, to the height of perhaps one hundred feet. It is the most elevated spot in the vicinity, and commands a wide and very beautiful prospect. The ground occupied by the work subsides gently from the centre of the area; but exterior to the walls are steep acclivities and deep ravines, rendering approach in nearly every direction extremely difficult. These natural features are indicated in the plan, which obviates the necessity for a detailed description. Upon the south are several deep gulleys, separated by sharp, narrow ridges, rendering ascent at this point, in the face of determined defenders, entirely impracticable. It has been conjectured by some that the walls here have been washed away; but it is clear that there was slight necessity for any defences at this point, and that none ever existed beyond what may still be traced.

The number and relative proportions of the gateways or openings are correctly shown in the plan. That upon the north is one hundred and sixty feet wide; that upon the east sixty feet, and that upon the west thirty feet. These wide, unprotected spaces would seem to conflict with the supposition, so well sustained by its remaining features, that the work had a defensive origin. It is not improbable, however, that palisades extended across these openings, as well as crowned the embankments; for without such additions, as has been already observed, the best of these structures could have afforded but very slight protection.

The embankments of this work are now between two and three feet in height, and the trenches of corresponding depth. The area of the work and the ground around it are covered with forest-trees. There are several depressions, which probably were the *caches* of the ancient occupants.*

It is said that a number of relics have been recovered here from time to time,

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* This work has an accidental approach to regularity; but it is far from being a true ellipsis, as has been supposed by some who have visited it.

and among others the head of a banner-staff of thin iron, fourteen inches long and ten broad. It is, of course, of French or English origin, and was probably lost or buried here by the Indians, into whose hands, by purchase or capture, it had fallen. We may perhaps refer it back to the days of Champlain and Frontenac, when the armies of France swept the shores of the western lakes, in the vain hope of laying the foundation of a Gallic empire in America. This relic is now in the possession of Mr. J. W. Chedell, of Auburn.

McCauley, in his History of New York, presents the subjoined facts bearing upon the question of the probable antiquity of this work, which may not be without their interest. He says: "We examined the stump of a chestnut-tree in the moat, which was three feet two inches in diameter, at a point two feet and a half above the surface of the earth. A part of the trunk of the same tree was lying by the stump. As this tree had been cut down, we endeavored to ascertain its age; and for this purpose we counted the rings or concentric circles, and found them to amount to two hundred and thirty-five. The centre of the tree was hollow, or rather decayed; and estimating this part as equal to thirty more layers or growths, we calculated the entire age of the tree to be two hundred and fifty-five years. About five years had elapsed since the tree was cut down. This was in 1825, and would carry back the date of the work to 1555.

"At the distance of three paces from this stump was another of chestnut, standing in the ditch. It exceeded three feet in diameter, and the tree must have died standing, and probably remained in that position many years before it fell from decay. In our opinion, the tree dated back as far as the discovery of the continent. Besides, it may be conjectured, for aught we know to the contrary, that several growths of forest intervened between the abandonment of this work and the date of the present forest."*

About two miles northeast of the work above described, upon elevated ground, was another similar work. It is now entirely levelled, and its site can only be ascertained by the fragments of pottery which are scattered over the ground. It was visible in 1825, when it was visited by McCauley, who says:

"It enclosed about two acres, and had a rampart, ditch, and gateway. It is now nearly obliterated by the plough. In its original state, or the condition it was in thirty-five years ago, about the time the land was cleared, the rampart was seven feet high, and the ditch ten feet wide and three deep. Two persons, the one standing in the ditch, and the other within the enclosure, were unable to see each other. The gateway was on the northeastern side, in the direction of a spring which flowed close by. The work was three hundred and fifty paces in circumference."

* History of New York, Vol. I., p. 112.

PLATE V. No. 2.

ANCIENT WORK, MENTZ TOWNSHIP, CAYUGA COUNTY, NEW YORK.

Six miles northwest of Auburn, and three miles from Troopsville, in the township of Mentz, is the small but well preserved work of which a plan is here given. The country around is hilly, and the work itself is built upon the crest of a narrow ridge, which extends nearly north and south, and along which the main road passes. There is a hollow, with springs flowing into it, towards the left; in which direction, it will be observed, a gateway opens. Although the ground has been for many years under cultivation, the lines of embankment are still between two and three feet high. A quantity of relics, some of comparatively late date, have been found here. Some skeletons, also, have been disclosed by the plough, both within and without the walls. The plan obviates the necessity for any further description.

The existence of this work does not seem to have been hitherto known, beyond the secluded vicinity in which it occurs. It is, however, probable that it is the one alluded to by McCauley in the following very indefinite terms: "On the east side of the Seneca River, near Montezuma, there are still to be seen the ruins of a small fort. A small mound occurs not far from the fort; it is artificial." Montezuma is situated in the same township with the work above described, and about four miles distant, in a northwestern direction. In the "New York Magazine," for 1792, mention is made of a couple of ancient works, said to occur south of Cross and Salt Lakes, east of the Seneca River, and falling probably within the limits of the present township of Brutus, in Cayuga or Elbridge, in Onondaga county. One of these was in the "form of a parallelogram, two hundred and twenty yards long and fifty-five broad, with openings on either side, one of which led to the waters. Half a mile south was another work of crescent form; large trees were growing upon both." Quantities of well burned pottery in fragments were found there; also a slab of stone five feet long, three and a half broad, and six inches thick, upon which were some rude tracings, specimens perhaps of the "picture writing" of the Indians.

McCauley mentions an ancient work near the town of Aurora, in the southern part of this county, and near Cayuga Lake. According to this authority, it was situated "two miles from the village, in a southwesterly direction; the area triangular, and containing two acres. Two of its sides were defended by precipitous banks, and the third by an embankment and ditch. Fragments of earthen vessels and the bones of animals had been found there enveloped in beds of ashes."

There are traces of an ancient palisaded work of the Cayugas, in Ledyard township, about four miles southeast of Springport. In fact, the whole country has numerous vestiges, cemeteries, etc., of its former aboriginal possessors.

CHEMUNG COUNTY.

THERE is a work in this county which possesses peculiar interest, from the circumstance that the embankments still retain unmistakable traces of the palisades with which it was crowned, thus demonstrating the correctness of the conjectures already indulged in, as to the probable construction of the entire system of earthworks of Western New York. The accompanying plan and description are from the note-books of Prof. E. N. Horsford, of Harvard University, who visited this work in company with other gentlemen connected with the State Geological Survey, at the time that enterprise was in progress.

PLATE VI. No. 1.

ANCIENT WORK NEAR ELMIRA, CHEMUNG COUNTY, NEW YORK.

" THIS work is situated about two and a half miles west of Elmira, upon the summit of an eminence, the base of which, upon one side, is washed by Chemung River, and upon the other by the waters of a deep and almost impassable ravine. It is, in fact, a bold headland. The approach is by a narrow path, which in some places will admit of the passage of a single person only, and which traverses the very abrupt crown of the ridge. Towards the top, the ascent is more gradual, and the ground continues to ascend slightly until we reach the defences. The site chosen exhibits the strongest proof of design, being such as to command a most extensive view along the course of the river, and being, except from behind, accessible only by the difficult pathway already mentioned.

" The artificial defences consist of an embankment, with an outer ditch, which extends, as shown in the plan, from the steep bank towards the river, to the brow of the ravine upon the other side. This embankment is about two hundred feet long, fourteen feet broad at the base, and about three and a half feet high. The rotting stump of an old pine-tree, three feet in diameter, and a yellow pine-tree, nine feet in circumference, are standing upon the wall, and indicate its high antiquity.

" What appeared to be a furrow was observed extending along the summit of the embankment throughout its entire length. Upon examination, it was found that this appearance was produced by a succession of *holes*, about a foot in depth.

Just within this chain of holes is another parallel chain, not quite so distinct as the first. Still further inwards, and extending but part of the way across the area of the work, are several parallel furrows, without accompanying ridges, the design of which is hardly apparent."

It will be seen that this work corresponds entirely in position with most of the earth-works of the State, was chosen with reference to the same principles, and was defended in precisely the same manner. It is peculiar in still retaining the holes left by the decay of the palisades, which show that it was strengthened by a double line. It is rational to conclude, upon general principles, that all the works of the State were protected in like manner; although, except in this instance, all traces of the wooden superstructure have disappeared. As already observed, this work, for the positive light which it throws upon the original character of these ancient defences, is probably the most interesting one in the State.

ONTARIO COUNTY.

PLATE VI. No. 2.

ANCIENT WORK NEAR CANANDAIGUA.

One mile east of the town of Canandaigua, upon the slope of a hill overlooking Canandaigua Lake, is the work here figured. It is unsurpassed for the beauty of its position. A considerable portion of the embankment has been obliterated by cultivation, and another portion by the turnpike road, from Canandaigua to Geneva, which passes through it. The parts which may yet be traced are appropriately indicated in the plan, and enable us to make out the original form of the work with sufficient exactness. In constructing the road, human bones in considerable quantities were disclosed on the brow of the hill, accompanied by the

usual rude relics of Indian art. It is mentioned by Mr. Schoolcraft, that the Senecas deduce their descent from the remarkable eminence upon which this work is situated.*

Between three and four miles west of Canandaigua, on the road to Victor, there is a long, narrow trench running nearly in a direction from N. E. to S. W. It may be traced, with occasional interruptions, for some miles, and has been erroneously, but very generally, believed to be a work of art. It marks the line of a long, narrow fissure in the limestone substratum, into which the earth has subsided. The water which accumulates in it sinks, to swell the volume of some subterraneous stream. The cause of this singular fissure is worthy of the inquiries of geologists.

Judge Porter, of Niagara, mentions another ancient enclosure, similar to that above described, in the vicinity of Canandaigua; but its locality could not be ascertained. It is probably now completely destroyed.

PLATE VII. No. 1.

ANCIENT WORK NEAR GENEVA.

One and a half miles west of Geneva are the traces of the old Indian "Castle" of *Ganundesâga*, built by the Senecas, and destroyed by Sullivan in 1779. Near it is a mound thickly covered over with graves. A plan and description of this work will be given in another connection. About two miles beyond, in the same direction, in Seneca township, is another work of more ancient date, a plan of which is here presented. It is situated upon elevated grounds, and coincides generally with those already described. The position upon the east side is protected by a steep, natural bank, perhaps sixty feet in height, which subsides into low, marshy grounds. At the foot of the bank is a copious and perennial spring. Upon the west, south, and north, the ground falls off gently; and here we find the artificial defences. Although the whole has been for some time under cultivation, the lines of entrenchment may be followed throughout nearly their entire extent, without difficulty. The usual evidences of ancient occupancy are found within the area.

Half a mile further to the westward, upon a corresponding site, are the traces of an ancient palisaded work, which will be described in its appropriate place.

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* Notes on the Iroquois, p. 196.

MONROE COUNTY.

A NUMBER of aboriginal monuments formerly existed in this county; but, with the exception of a few small mounds, they have been wholly obliterated or so much defaced that they can no longer be made out. Two mounds occupy the high, sandy grounds to the westward of Irondequoit Bay, where it connects with Lake Ontario. The point is a remarkable one. The position of the mounds in respect to the natural features around is indicated in the accompanying sketch, Plate VII. No 2.

They are small, the largest not exceeding five feet in height. It was found upon excavation that they had been previously disturbed; and their examination proved fruitless. Some bits of charcoal and a few small fragments of bones were observed mingled with the sand. At various places, upon the elevations around them, were scattered fragments of pottery, and arrow-heads and other rude relics are also of frequent occurrence here.

The spot was evidently a favorite one with the Indians, the vicinity abounding in fish and game.

The waves of the lake have thrown up a narrow bar or bank of sand, called the "*Spit*," which extends nearly across the mouth of the bay, leaving but a small opening. Upon this bar, a few scattered trees are standing, and it was here that the Marquis De Nonville landed with his troops, at the time of his expedition against the Senecas, in 1687. He constructed a stockade at or near this point.

Upon the eastern shore of the bay, and occupying a position corresponding with that of the mounds already described, it is said there is another mound of considerable size. It was opened many years ago, and was found to contain human bones.

Some eight or ten miles to the southeastward, and half a mile east of the village of Penfield, on the banks of Irondequoit Creek, is still another mound, situated upon a headland, which now projects into an artificial pond. It must have been originally eight or nine feet in height, by perhaps forty feet base. It is a favorite haunt of "money-diggers," by whom it has been pretty thoroughly excavated. A shaft had been sunk in it but a short time before it was visited by the author; and at that period many fragments of human bones, much decayed, which had been thrown up from near the base, were bleaching upon the surface. The soil is here light and sandy, and a depression is still visible near by, marking the spot whence the material composing the mound was procured. It could not be ascertained that any relics of art were obtained here. See Plate VII. Fig. 3.

As already observed, most, if not all, of the ancient works which existed in this county are now obliterated. We can consequently do but little more than indi-

cate the sites which they occupied according to the best information obtained from the early settlers. It is asserted that an enclosure of considerable size exists in the town of Irondequoit, west of Irondequoit Bay, and near the Genesee River, about five miles north of Rochester. A day was spent in search of it, but without success. Its discovery may reward the perseverance of some future explorer.*

A fine work once occupied a commanding site at the point known as "Handford's Landing," three miles north of Rochester. It consisted of a semicircular embankment, the ends of which extended to the very edge of the immense ravine which shuts in the Genesee River below the falls at Rochester. It had three narrow gateways placed at irregular intervals.

There is a locality in the town of Parma, about seven miles west of Rochester, where the earth has subsided into the fissures of the sand rock, forming what has generally been supposed to be a line of entrenchments. From some distance the apparent ditch has all the regularity of a work of art; but still it is hard to understand how it came to be regarded as an "Indian Fort," by which name it is currently known in the neighborhood. It would seem incredible that errors of this kind should become general, had not a large experience shown that upon no class of subjects do the mass of men exercise so little sound judgment, as upon those which relate to the history and monuments of the past.

In the town of Ogden, which adjoins Parma on the south, it is reputed that some ancient works are to be found; but from the best information which could be obtained, it seems probable that the report has no better foundation than hundreds of similar ones, and originated, it is very likely, in the discovery of an Indian cemetery, or of the traces of an Indian village.

Ascending the valley of the Genesee for twenty miles, we come to a section of country which is very rich in evidences of aboriginal occupancy, but chiefly such as may be referred to a comparatively late date. In the town of Wheatland, and a short distance to the westward of the village of Scottsville, there formerly existed two very interesting earth-works. There is scarcely a trace of them now to be seen. They were visited by Kirkland in 1788. He found the first work "about two miles west of Allen's residence, which was an extensive flat, at a deserted Indian village near the junction of a creek (Allen's Creek) with the Genesee, eight miles north of the old Indian village of *Kanawageas*, and five miles north of the *Magic Spring* (Caledonia Springs), so called by the Indians, who believed its waters had the power of petrifying all things subjected to its influence. This work enclosed about six acres, and had six gates. The ditch was about eight feet wide, and in some places six feet deep, and drawn in a circular form on three sides. The fourth side was defended by nature with a high bank, at the foot of which was a fine stream of water. The bank had probably been secured by a stockade, as there appeared to have been a deep covered way in the middle of it,

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* McCauley states that there is an ancient work on Irondequoit Bay, in Penfield township, on the north side of the "ridge." No information could be obtained concerning it.

down to the water. Some of the trees on the work appeared to be two or three hundred years old."

The usual variety of relics, fragments of pottery, stone chippings, etc., have been found upon the site of this work. About half a mile south of this, and upon a greater eminence, Mr. Kirkland traced another work, "of less dimensions than the first, but with a deeper ditch, and in a situation more lofty and defensible." Although it is well remembered by the older settlers in the neighborhood, nothing now remains to indicate that it ever existed, except the greater abundance of stones on the line of the former embankment. The position is such as the builders of these works usually selected for their defences. Upon one side is a high and precipitous bank, at the base of which flows Allen's Creek; and in every other direction the ground slopes gently. It is altogether a well chosen and very beautiful site. About three miles south of these works, on the bank of the Genesee River, and probably falling in Caledonia township, Livingston county, are to be observed the traces of a mound. It was originally about eight feet high, and was filled with human bones heaped promiscuously together. Still another mound is said to occur a few miles N. W. of Scottsville, in the town of Chili.

Near the village of West Rush, in the town of Rush, upon the banks of Honeoye Creek, were formerly two considerable enclosures. One of these was situated immediately upon the bank of the creek, which defended it upon one side; while the other occupied higher ground a hundred rods to the southward. Each contained about four acres, and the embankments were originally four feet in height. A few slight depressions indicating the ancient *caches*, with fragments of pottery scattered around, alone remain to mark the sites of these structures.

The whole of this country was occupied by the Senecas; and their cemeteries, and the traces of their ancient forts and towns, are particularly numerous along the Genesee River, and on the banks of the Honeoye. We shall refer to these in another place.

LIVINGSTON COUNTY.

This county, which adjoins Monroe on the south, was also a favorite ground with the Senecas. It is unsurpassed in beauty and fertility by any territory of equal extent in the State, and abounds with mementoes of its aboriginal possessors, who yielded it reluctantly into the hands of the invading whites. Here, too, once existed a considerable number of ancient earth-works, but the levelling plough has passed over most of them; and though their sites are still remembered by the early

settlers, but few are sufficiently well preserved to admit of exact survey and measurement.

"In 1798," says the venerable Judge Augustus Porter, of Niagara, in a letter to O. H. Marshall, Esq., of Buffalo, "I surveyed the Indian Reservation of *Kanawageas.* There were then in the open flats of the Reservation the embankments of an old fort, which included very nearly two acres. It corresponded in situation and appearance with many others which I have seen in this part of the country, and which seem to bear a high antiquity." The Kanawageas Reservation embraced the township of York in this county.

Judge Porter also mentions that he knew of two other works on the "Smith and Jones's Flat," near Mount Morris, (also in Livingston county,) all of which had the same appearance.

A work also occurs in the town of Avon, not far from the beautiful village of Avon Springs, upon the flats of the Genesee River. It is described by W. H. C. Hosmer, Esq., in the notes to his poem of "Yonondio."

Another and very similar work once existed in the northeastern part of Avon township, about two and a half miles from the village of Lima. Some portions of the lines may yet be traced, but with difficulty.

PLATE VIII. No. 1.

ANCIENT WORK, LIVONIA TOWNSHIP, LIVINGSTON COUNTY, NEW YORK.

The work here represented occurs in the township of Livonia, three miles N. E. of the village of that name. It is situated upon the summit of a commanding hill, and is the largest enclosure which fell under the notice of the author, within the limits of the State. It has an area of not less than *sixteen acres.* Where the lines of the entrenchment were crossed by fences, and consequently preserved from the encroachments of the plough, the embankment and ditch are distinctly visible. Elsewhere, however, the outlines can only be traced by a very gentle undulation of the ground, and by the denser verdure on the course of the ancient trench. With the assistance of Mr. Haddock, the proprietor of the estate, who knew the work before it had been materially impaired, the original form was made out with entire satisfaction. General Adams, who had often been over the grounds before the removal of the forest, states that the ditch was breast deep, and the embankment of corresponding height. *Caches* were formerly discovered here, and fragments of pottery are now abundant.

The enclosure had four gateways, one of which, at the northwestern extremity, opened directly towards a copious spring of water, as shown in the plan. It was thought by General Adams, from certain indications (which might have been

caused by the decay of palisades), that slight parallel embankments extended down the slope of the hill, and enclosed the spring here referred to. Be that as it may, the position was well chosen for defence, for which purpose the work was doubtless constructed.

A mile and a half to the southward are remains of some old fortified towns of the powerful tribe of the Senecas, for plans and descriptions of which the reader is referred to the chapter on "Palisaded Works."

It is said that a mound, containing a large number of human bones, occurs near the head of Hemlock Lake, in the township of Springwater; but no opportunity was afforded of visiting it. At various places in the county large cemeteries are found; but most, if not all, of them may be with safety referred to the Senecas. Indeed, many articles of European origin accompany the skeletons. A cemetery of large size, and, from the character of the relics found in the graves, of high antiquity, is now in part covered by the village of Lima. Pipes, pottery, etc., are discovered here in great abundance; and it is worthy of remark, they are identical with those found within the ancient enclosures.

A number of ancient works are reported to exist higher up the Genesee River, in the southern part of Livingston and in Alleghany counties; but this entire region has been brought so thoroughly under cultivation, that it was esteemed hopeless to look for them with a view to their survey or measurement. The only information of any authentic kind which was received in addition to what is here presented, relates to a remarkable work upon a high hill, not far from the falls of the Genesee, in Alleghany county. Says Judge Porter, in a private letter dated Niagara Falls, November 18th, 1848: "Upon the west side of Genesee River, a mile or two above the falls, there is a hill, the base of which may perhaps cover two acres of ground, circular in form, and shaped like a sugar-loaf, with a truncated summit a fourth of an acre in area. Upon this summit is a breastwork. The height of the hill is between eighty and one hundred feet. I visited it in 1798, before any settlements were made by the whites nearer than Mount Morris."

Mr. Moses Long, of Rochester, describes a work which is substantially the same, as follows: "About four miles above the village of Portage, in Alleghany county, is a circular mound or hill, which rises probably a hundred feet above the surrounding interval or 'bottom' lands. The acclivity is steep on all sides. The Genesee River curves around its base, describing nearly a semicircle, and then sweeps on in a tortuous course to the cascades or cataracts below the village of Portage. The top of the hill is quite level, covered thinly with small forest-trees, and its area may comprise an acre. There are appearances of an entrenchment around that part of the summit unprotected by the river.

"My guide informed me that he had been acquainted with *Shongo*, an aged chief, and several other Indians of the Caneadea Reservation, who all concurred in saying, that they had no knowledge nor any tradition in relation to this work. *Shongo* remembered the invasion of Sullivan, when the Indians cut up their corn and threw it into the river, and then retreated with their movable effects a few

miles up the stream to the top of an elevated bluff, where they determined to await the attack of their enemy. I came to the conclusion that the entrenchment might have been made by an advanced detachment from Sullivan's army."

GENESEE COUNTY.

A NUMBER of very interesting remains formerly existed in this county; but few of them are sufficiently well preserved to be satisfactorily traced.

In the town of Alabama, in the extreme northwest of the county, were once three of these works, all of small size. The plough has completely defaced them. This town adjoins the town of Shelby, in Orleans county, on the south; and touches Newsted, in Erie county, on the west. It will ultimately be seen that its ancient works constitute part of a chain extending from the "Lake Ridge" on the north to Buffalo Creek on the southwest, a distance of fifty miles. Not less than twenty ancient works are known to occur within this range.

PLATE VIII. No. 2.

ANCIENT WORK, OAKFIELD, GENESEE COUNTY, NEW YORK.

IN the town of Oakfield, half a mile west of the little village of Caryville, is found the ancient enclosure, a plan of which is here given. It is remarkable as being the best preserved and most distinct of any in the State which fell under the notice of the author. It is situated upon the western slope of one of the billowy hills which characterize the rolling lands of the West, and between which the streams find their way to the rivers and lakes. The banks of the little stream which washes the work upon the north are steep, but not more than ten feet in height. Upon the brow of the bank, where the stream approaches nearest the work, the entrenchment is interrupted, and the slope towards the water is more gentle than elsewhere,—indicating an artificial grade. The plan obviates the necessity for a detailed description. The embankments will now probably measure six feet in average height, measuring from the bottom of the trench. In the part of the work under cultivation, it is easy to trace the ancient lodges. Here, too, is to be found the unfailing supply of broken pottery. At the sides of the princi-

pal gateway (*a*), leading into the enclosure from the east, according to the statement of an intelligent aged gentleman, who was among the earliest settlers in this region, traces of oaken palisades were found, upon excavation, some thirty years ago. They were, of course, almost entirely decayed. A part of the area is still covered with the original forest, in which are trees of the largest dimensions. An oaken stump upwards of two feet in diameter stands upon the embankment at the point *b*.

About one mile northeast of this work was originally a large enclosure, but which is now entirely destroyed. It was called the "*Bone Fort*," from the circumstance that the early settlers found within it a mound, six feet in height by thirty at the base, which was entirely made up of human bones slightly covered with earth. A few fragments of these bones, scattered over the surface, alone mark the site of the aboriginal sepulchre. The popular opinion concerning this accumulation is, that it contained the bones of the slain, thus heaped together after some severe battle. It will, however, be seen that it probably owed its origin to the same practice to which we are to attribute the "*bone pits*" found elsewhere, that of collecting together at stated intervals the bones of the dead—a practice very prevalent among the northwestern Indians.

There is no doubt but this is one of the works visited by Rev. Samuel Kirkland, Missionary to the Senecas, in 1788. His MS. Journal was in the possession of Messrs. Yates and Moulton, who have given a synopsis of the part relating to this group of remains in the subjoined passages.

"Having examined the works (already referred to, in Monroe county) on the Genesee, he returned to *Kanawageas*, and resumed his journey west, encamping for the night at a place called *Joaika*, i. e. Raccoon (Batavia), on the river *Tonawande*, about twenty-six miles from *Kanawageas*. Six miles from this place of encampment, he rode to the open fields, and arrived at a place called by the Senecas *Tegataineáaghgue*, which imports a '*double-fortified town*,' or a town with a fort at each end. Here he walked about half a mile with one of the Seneca chiefs, to view the vestiges of this double-fortified town. They consisted of the remains of two forts: the first contained four acres of ground; the other, distant about two miles, at the other extremity of the ancient town, enclosed about eight acres. The ditch around the first was about five or six feet deep. A small stream of water and a high bank circumscribed nearly one third of the enclosed ground. There were traces of six gates or openings, and near the centre a way was dug to the water. The ground on the opposite side of the water was in some places nearly as high as that on which the fort was built, which might render this covered way to the water necessary. A considerable number of large thrifty oaks had grown up within the enclosed ground, both in the ditch and upon the wall; some of which appeared to be two hundred years old or more. The ground is of a hard, gravelly kind, intermixed with loam, and more plentifully at the brow of the hill. At some places at the bottom of the ditch, Mr. Kirkland ran his cane a foot or more in the soil; from which circumstance he concludes that the ditch was much deeper originally.

"Near the western fortification, which was situated on high ground, he found the remains of a funeral pile, where the slain were buried after a great battle,

which will be spoken of hereafter. The mound was about six feet in height by thirty feet diameter at the base. The bones appeared at the surface, projecting at many places at the sides.

"Pursuing his course towards Buffalo Creek, (his ultimate destination,) Mr. Kirkland discovered the vestiges of another fortified town. He does not delineate it in his MSS., but says: 'On these heights, near the ancient fortified town, the roads part; we left the path leading to Niagara on our right, and went a course nearly southwest for Buffalo Creek. After leaving these heights, which afforded an extensive prospect, we travelled over a fine tract of land for about six or seven miles, then came to a barren white-oak shrub plain. We passed a steep hill on our right, in some places fifty feet perpendicular, at the bottom of which is a small lake, affording another instance of pagan superstition. The old Indians affirm that formerly a demon, in the form of a dragon, resided in this lake, which frequently disgorged balls of liquid fire. To appease him, many sacrifices of tobacco had been made by the Indians. At the extremity of the barren plain, we came again to Tonawande River, and forded it about two miles above the Indian town of that name. At a short distance on the south side of the same stream, is another fortification.'"

FIG. II.

ANCIENT WORK, LE ROY, GENESEE COUNTY, NEW YORK.

Remnants of another ancient work occur in the town of Le Roy, three miles north of the village of the same name, in the southeastern part of this county.

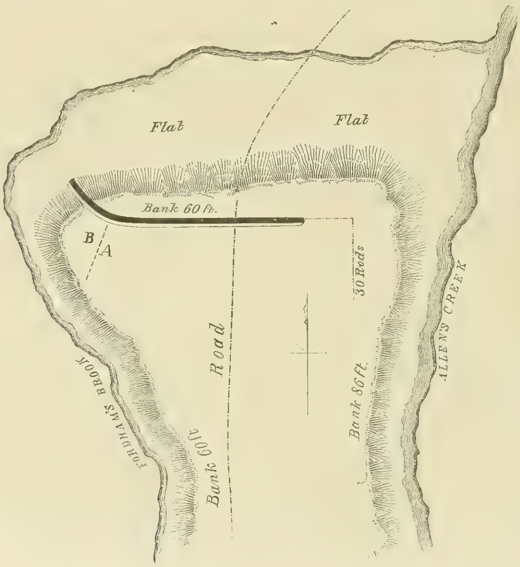

Fig. 2.

The accompanying sketch, by L. H. Morgan, Esq., of Rochester, although not from an exact instrumental survey, is sufficiently accurate for all essential purposes.

The position which the work occupies is a portion of a high plain or table-land, nearly surrounded by deep ravines, bounded by Fordham's Brook and Allen's Creek, which effect a juncture at this point. These streams have worn their beds through the various strata of lime and sandstone to the depth of from seventy to one hundred feet, leaving abrupt banks difficult of ascent. These natural features are best illustrated by the plan, which precludes the necessity for a minute description.

The peninsula measures about 1300 feet from north to south, by 2000 feet at its broadest part, and 1000 feet across the neck connecting it with the general table. Positions similar to this were often selected by the aborigines for defensive purposes, but in such cases have usually an embankment and trench extending across the isthmus. In this instance, however, the only trace of art is an embankment and ditch, about 1500 feet in length, and running nearly east and west across the broadest part of the peninsula, and not very far back from the edge of the ravine. The part which is laid down in the plan is said to be still very distinct; the embankment being between three and four feet in height, and the ditch of corresponding depth. The western extremity of the line curves gently outwards, and extends some distance down the bank, which is at this point less abrupt than elsewhere. It is said that formerly trenches existed on the courses indicated by dotted lines on the plan; but the statement is not confirmed by any remaining traces.

A number of skeletons have been found here, together with many fragments of pottery. There have also been discovered some heaps of small stones; which have been supposed to be the missiles of the ancient occupants of the hill, thus got together to be used in case of attack. Various relics of art, pipes, beads, stone hatchets, arrow-heads, etc., have been disclosed here by the operations of agriculture. One of the pipes composed of baked clay is now in the possession of Rev. C. Dewey, of Rochester. It is represented of half size in the accompanying engraving, Fig. 3. The material is very fine, and the workmanship good; so good indeed, as to induce some doubt of its aboriginal origin. Another pipe carved from granular limestone was found here, as were also a number of beads, long and coarse, made of clay and burned.

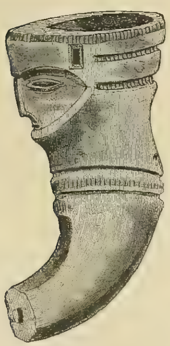

Fig. 3.

According to Mr. Dewey, "the trench was estimated by the early observers at from eight to ten feet deep and as many wide. The earth in making it had been thrown either way, but much of it inwards. The road formerly crossed it by a bridge. When first known, forest-trees were standing both in the trench and on its sides. In size and growth they corresponded with the forests around them. Prostrate upon the ground were numerous trunks of the heart-wood of black cherry trees of larger size, which, it is conjectured, were the remains of more

antique forests, preceding the growth of beech and maple. They were in such a state of soundness as to be employed for timber by the early settlers."*

From all that remains of this work, it is impossible to conjecture for what purposes it was constructed. Indeed, it bears so few evidences of design, that we are led to distrust its artificial origin; a distrust which is strengthened by the circumstance, that in a number of instances, elevations and depressions bearing some degree of regularity, but resulting from fissures in a rock substratum or other natural causes, have been very generally mistaken for works of art. The fact that the trench in this instance has a course so nearly parallel with the edge of the ravine, is also a suspicious circumstance. The spot was not visited by the author; but he is authorized in saying that Prof. Dewey, who gave the first and most complete account of the supposed work, is now inclined to the opinion that it may be the result of natural causes.

On what is called the "Knowlton Farm," about one mile south of the town of Batavia, is a small natural elevation which was used as a burial-place by the Indians. It has been mistaken for a mound. Various relics have been discovered in ploughing over it.

ORLEANS COUNTY.

It is not known that many ancient remains occur in this county. There is, however, an interesting work in Shelby township, one and a half miles west of Shelby Centre. The following account of it was communicated by Dr. S. M. Burroughs, of Medina, to O. Turner, Esq., of Buffalo, by whom it was presented to the author.

"It consists of a ditch and embankment, enclosing, in a form nearly circular, about three acres of ground. The ditch is still well defined and several feet in depth. Adjoining this fortification on the south is a swamp, about one mile in width by two in length; which was once, if not a lake, an impassable morass. There is a passage-way through the lines of the entrenchment towards the swamp, and this is the sole gateway discoverable. Large quantities of small stones, of a size to be thrown with the hand, are accumulated in piles within and near the work. Here, too, are many arrow-heads of flint (*silex*), stone axes, and fragments of pottery, exhibiting ornaments in relief. Human skeletons almost entire have been exhumed here. Half a mile west of the fort on a sand-hill, an immense number of skeletons have been found in a very perfect state. Many seem to have been deposited in the same grave. As some of the skulls appear to have been broken by clubs or tomahawks, is it not probable that this was the site of some great battle?"

* Schoolcraft's Notes on the Iroquois, p. 203.

ERIE COUNTY.

Erie county ranks next to Jefferson in the number of its ascertained aboriginal monuments. The topographical features of the two counties are much the same, although the former is by far the least elevated. Along the shores of Lake Erie and bordering Buffalo Creek are low and fertile alluvials; back of these we come to the limestone formation, and the country rises, forming a second grand terrace, along the brow of which most of the ancient works are situated. Within the limits of the late Seneca Reservation, which has been only in part brought under cultivation, there are a number of ancient works, which are unimpaired except by the operation of natural causes. It is extremely difficult, however, to find them, in consequence of the forest and the thick undergrowth. As the Reservation is cleared up, no doubt new ones will be discovered; and it is to be hoped sufficient interest in these matters may be found to exist among the citizens of Buffalo, to secure their prompt and careful investigation.

PLATE IX. No. 1.

ANCIENT WORK NEAR BUFFALO.

One of the most interesting works in this county is that here represented. It derives much of its interest from the associations connected with it. The site which it occupies was a favorite spot with the Senecas, and one of their largest cemeteries occurs within its walls. Here is buried an Indian chief whose name is inseparably interwoven with the history of the Five Nations. He was a man who possessed a rare combination of talents, which, developed under different circumstances, would have secured for him a high position among the greatest statesmen and proudest orators of the world. This is hardly a proper place to speak of his character; but his devoted patriotism, his inflexible integrity, the unwavering firmness, calm and lofty dignity, and powerful eloquence with which he opposed the encroachments of the whites, notwithstanding that he knew all resistance was vain and hopeless—command an involuntary tribute to the memory of the last and noblest of the proud and politic Iroquois, the haughty and unbending Red Jacket,

who died exulting that the Great Spirit had made him an Indian! Here, too, is buried Mary Jemison, " the white woman," who, taken a prisoner by the Indians when a child, conformed to their habits, became the wife of one of their chiefs, and remained with them until her death. The story of her life is one of the most eventful of those connected with our border history, filled as it is with thrilling adventures and startling incidents.

The work under notice is situated upon the edge of the second terrace, which is here moderately elevated above the fertile alluvials bordering Buffalo Creek. The particular spot which it occupies is considerably higher than any other near it, and the soil is sandy and dry. It will be seen that the terrace bank upon one side is made to subserve the purposes for which the trench and embankment were erected upon the others. There is now no direct evidence to that effect; but no doubt can be entertained that, in common with all the other works of the State, the wall was crowned with palisades, which were also carried along the brow of the terrace. The greater portion of this work has been for some time under cultivation; and the original lines are so much defaced, that they would probably escape the notice of the careless observer. They may, nevertheless, be distinctly traced throughout their extent. At the point nearest the Indian cemetery, a portion of which is still spared by the plough, the embankment is very distinct, and cannot fail to attract attention. At a short distance to the northward of the work is a low spot of ground or marsh, towards which opens a gateway. From this was probably obtained a portion of the supply of water required by the ancient occupants of the work. A number of springs start from the foot of the terrace where the ground is also marshy. Within the walls of this work are to be found the various traces of occupancy which I have already mentioned, sites of old lodges, fragments of pottery, etc.

Tradition fixes upon this spot as the scene of the final and most bloody conflict between the Iroquois and the " *Gah-kwas* " or Eries,—a tradition which has been supposed to derive some sanction from the number of fragments of decayed human bones which are scattered over the area.

The old mission-house and church stand in close proximity to this work. The position of the former is indicated in the plan. Red Jacket's house stood above a third of a mile to the southward upon the same elevation; and the abandoned council-house is still standing, perhaps a mile distant, in the direction of Buffalo. A little distance beyond, in the same direction and near the public road, is a small mound, called " *Dah-do-sot*," artificial hill, by the Indians, who it is said were accustomed to regard it with much veneration, supposing that it covered the victims slain in some bloody conflict in the olden time. A genuine representative of the Celtic stock had selected it as the site of his cabin, and his worthy but somewhat superstitious spouse was much horrified at the intimation that it probably contained the bones of the unsanctified heathen. A shaft was sunk near the foundation of the cabin to the base of the mound, but nothing of interest was disclosed. A few half-formed arrow-heads, some chippings of hewn stone, and some small bits of charcoal were discovered, intermingled with the soil thrown from the excavation. Whatever deposits are contained in the mound, if any, probably occur

immediately beneath the apex which is occupied by the cabin of the Celt aforesaid. Its investigation is therefore reserved for the hands of some future explorer. It was originally between five and six feet in height by thirty-five or forty feet base, and is composed of the adjacent loam. A depression still exists upon one side, marking the spot whence the material was obtained.

PLATE IX. No. 2.

ANCIENT WORK, LANCASTER, ERIE COUNTY, NEW YORK.

It is not known that any ancient remains occur nearer the work last described than the one here presented, which is situated upon lot No. 2, of the late Reservation, about four miles southeast of the village of Lancaster, near Little Buffalo Creek. It occurs upon the summit of a small eminence, in the midst of a dense and tangled forest, and is reached by a bridle path which passes through it. It approaches more nearly to the form of a true circle than any work which fell under the observation of the author in Western New York. It is small, containing less than an acre. The embankment is however very distinct, being not less than three feet in height, and the ditch of equal depth. Trees, corresponding in all respects with those of the surrounding forest, are standing within the area and upon the wall. The ground is here gravelly and dry. A number of *caches* of considerable size were observed within the enclosure.

PLATE IX. No. 3.

ANCIENT WORK, LANCASTER, ERIE COUNTY, NEW YORK.

Half a mile to the southeast of the above work, and as nearly as could be ascertained on lot No. 6, is a work of larger size and more irregular outline. It occupies a beautiful level spot of ground not far from the edge of the second terrace back from the creek. The embankment is somewhat higher than that of the previous work, and, with a single exception, quite as well defined as any observed within the State. It is very slightly reduced from its original height, which may be estimated as having been between seven and nine feet, measuring from the bottom of the ditch. At the point indicated by the letter *a* upon the embankment is

standing the stump of a withered pine-tree, which is sixteen feet in circumference six feet above the roots. A few rods to the southward of the work is a narrow ravine leading off towards Little Buffalo Creek. Within this is a spring from which flows a small stream. It will be observed that two of the gateways of the work placed not far apart open in this direction—leading to the inference that it was here that the water used by the ancient occupants was obtained. A number of large *caches* also occur within this work.

PLATE X. No. 1.

ANCIENT WORK ON LATE INDIAN RESERVATION, ERIE COUNTY, NEW YORK.

Upon the opposite bank of the creek already named, and probably on lot No. 3 of the Reservation, is the singular work here presented. The land upon this side of the creek rises abruptly to the height of 150 or 200 feet, forming a high bluff. The edge of this bluff is cut by ravines into spurs or head-lands; and upon one of these the work under notice is situated. It is not large, and is singular only in having wide interruptions in the embankment—so wide indeed, that were it not from the perfect condition of the lines where they exist, it might be conjectured that the structure was never completed. *Caches* were noticed here. The ground is covered with a dense forest, which obscures all parts of the work.

To the southwestward of this, on lot 29 of the same range and on the south side of "Big Buffalo Creek," is still another similar work, which is described by Mr. Junius Clark, in a private communication, as about eight hundred feet in circumference, having three gateways and an open space ten rods wide at the southwestern corner. A gateway on the north opens towards a spring of water, distant about a dozen rods. Other works, probably differing in no essential respect from these, are said to occur at various places upon the southern border of the Reservation.

PLATE X. No. 2.

ANCIENT WORK, CLARENCE TOWNSHIP, ERIE COUNTY, NEW YORK.

Passing northward from the localities last mentioned to the distance of five or six miles, keeping upon the limestone plateau, we find another series of remains,

composed of a succession of works placed a mile or two apart, and extending quite through the town of Clarence. The first of these (No. 2) is two and a half miles south of the little village of "Clarence Hollow." It has been under cultivation for a number of years, and its outlines can now be traced only by carefully observing the stronger vegetable growth upon the course of the ancient trench. Where fence lines crossed the wall, short sections of the embankment are yet visible. Fragments of pottery are scattered over the area. If any of the usual pits ever existed, they have been filled up by the operations of agriculture.

PLATE X. No. 3.

ANCIENT WORK, CLARENCE TOWNSHIP, ERIE COUNTY, NEW YORK.

A MILE northward of the work last described, and occupying a position in no respect well adapted for defence, is the enclosure here presented. It is now much defaced; the part, however, which has never been cultivated is very distinct, and one or two other short sections may yet with some difficulty be traced. Flint chippings, fragments of pottery, and a number of deep *caches* occur within the area. A large Indian cemetery is said to exist somewhere between this work and the one just noticed. However true this may be, about half a mile to the northwest on the land of a Mr. Fillmore there is a large deposit of bones, a "*bone pit*," some fourteen feet square and four or five in depth, filled with crumbling human skeletons. The spot was marked by a very slight elevation of the earth a foot or too in height.

A couple of miles distant, still following the brow of the terrace, and not far back of the village of Clarence, was formerly another similar work now completely destroyed. Still a mile beyond is another, (Plate XI. No. 1.,) which, although upon grounds which have been cleared, is yet perfect. It is situated upon a sandy, slightly elevated peninsula, which projects into a low tangled swamp. A narrow strip of dry ground connects it with the higher lands, which border the swamp on the south. It is small, containing less than an acre. The embankment does not preserve uniform dimensions, but has perhaps an average height of three feet. The ditch too is irregular, both in width and depth, owing probably in some degree to the rocky substratum, which in some places comes nearly or quite to the surface of the ground. The stumps of immense pine-trees are standing within the work, as also upon its walls. Here, too, are to be found *caches*, fragments of pottery, etc. The position, for purposes of concealment and defence, is admirably chosen, and recalls to mind the famous stronghold of the Narragansetts in Rhode Island, destroyed in 1676 by the New England colonists under Winthrop and Church.

A short distance from this work, upon the brow of a neighboring elevation, a number of human skeletons have been exposed by the plough. They probably mark the site of an Indian cemetery. A mile to the eastward, upon a dry sandy spot, is another of the "bone-pits" already several times referred to, which is estimated, by those who excavated it originally, to have contained *four hundred* skeletons heaped promiscuously together. They were of individuals of every age and sex. In the same field are found a great variety of Indian relics, also brass cap and belt plates, and other remains of European origin. Not far distant, some lime burners discovered, a year or two since, a skeleton surrounded by a quantity of rude ornaments. It had been placed in a cleft of the rock, the mouth of which was covered by a large flint stone.

Passing onward in the same direction which we have been pursuing, we come to the Batavia and Buffalo road, the great thoroughfare over which, previous to the construction of the railroad and canal, passed the entire western trade and travel. Here, at a point a few miles from Clarence, known as the "Vandewater Farm," are the traces of another work. A few sections alone remain, barely sufficient to indicate that it was of considerable size. The road passes through its centre.

PLATE XI. No. 2.

ANCIENT WORK, FISHER'S FALLS, NEWSTED TOWNSHIP, ERIE COUNTY, NEW YORK.

THE sole remaining work in this county which was personally examined by the author is the one here presented. It is situated five miles eastward of the locality last noticed, at a place known as "Fisher's Falls," in the town of Newsted, upon the banks of a creek, at present barbarously designated "Murder Creek." The creek here plunges down into a deep, narrow gorge with precipitate banks, which continues to the edge of the terrace a fourth of a mile distant. The relative position of the work, which is of large size, is correctly designated on the plan. It is now under cultivation, and is much reduced from its original elevation, but can be traced without difficulty throughout its extent. The older inhabitants affirm that the walls were originally five feet in height, and the ditch of corresponding proportions. Traces of the ancient *caches* are yet to be observed; and without the enclosure is a rock, the surface of which bears a number of artificial depressions hollowed out by the Indians,—the rude mortars in which they pounded their corn.

This work occurs upon the old Indian trail, which extended from the Genesee River to Batavia, and thence to Buffalo and Niagara. A branch of this trail, after

striking the limestone ledge at Tonawanda Creek, followed along its brow to Buffalo Creek. It diverged inwardly at the point under notice, so as to escape the impassable ravine already mentioned. Kirkland, missionary to the Senecas in 1787, passed along this trail on his way to Buffalo, and incidentally refers to a work which he encountered after crossing Tonawanda Creek, and which is probably the one here figured.

Besides the ancient remains here noticed, there are no doubt many others of which no information has yet been obtained. It is not probable, however, that they possess any novel features, or differ materially in any respect from those already described. Some "bone-pits" in addition to those already mentioned occur in Clarence township, and will be noticed in another connection.

This county abounds in traces of recent Indian occupancy; in fact the rude cabins of the aborigines have scarcely crumbled away, since they deserted their favorite haunts upon the banks of the Buffalo Creek and its tributaries. A small band are at bay upon the borders of the Tonawanda, sullenly defying the grasping cupidity of those who Shylock-like, sustained by fraudulent contracts, are impatient to anticipate the certain doom which impends over this scanty remnant, and would deny these the poor boon of laying their bones beside those of their fathers.

CHAUTAUQUE COUNTY.

This county abounds in ancient monuments; but no opportunity was afforded of examining them during the progress of the investigations here recorded. It is probable they are but a continuation of the series extending through Erie county, (which adjoins Chautauque on the northeast,) and it is not likely they present any new features.

One of the most remarkable occupies an eminence in Sheridan township, four miles east of Fredonia, on the banks of Beaver Creek. It corresponds in all respects with the hill-works already described. Another of like character occurs in the southern part of the same township.

MONTGOMERY COUNTY.

PLATE XII.

ANCIENT WORK, MINDEN TOWNSHIP.

The work here figured is in many respects the most remarkable in the State. It is the only one known which is situated upon waters flowing into the Hudson River. Its nearest neighbors upon the west are the ancient works in Onondaga county, a hundred miles distant. Between it and the Atlantic, we are not aware of the existence of a single monument of like character.

It occurs upon the banks of the Otstungo Creek, a branch of the Otsquago,—itself a tributary of the Mohawk, about four miles in a southwestern direction from Fort Plain, in the town of Minden. It is known in the vicinity by the name of "*Indian Hill.*" The position is admirably chosen, and is naturally by far the strongest and most defensible of any which fell under the observation of the author in the entire course of his explorations in this State. It is a high point of land projecting into a bend of the creek, which upon one side has cut away the slate rock, so that it presents a mural front upwards of one hundred feet in height, and entirely inaccessible. Upon the opposite side is a ravine, within which flows a small stream. Here the slope, though not precipitous, is very abrupt; and if a line of palisades were carried along its brow, it would be entirely inaccessible to a savage assailant. Across the narrow isthmus which connects this head-land with the adjacent high grounds, is an embankment and ditch two hundred and forty feet in length, extending from the precipice upon the south to the brow of the ravine on the north, along which, curving inwards, it is carried for some distance, terminating at a gigantic pine six feet in diameter. It has been supposed by some that this tree has grown upon the embankment since it was erected; but it seems most likely that it was the starting point of the ancient builders. The wall is not of uniform height, but at the most elevated point rises perhaps six feet above the bottom of the ditch. No gateway is apparent, but one may have existed where the "wood road" now crosses the entrenched line. The plan will afford an accurate idea of the position and its natural strength. The enclosed area is about seven hundred feet long by four hundred and fifty broad at its widest part, and contains very nearly six acres. It is densely covered with immense pines throwing over it a deep gloom, and, with the murmur of the stream at the foot of the precipice, impressing the solitary visitor with feelings of awe, which the professed antiquary might deem it a weakness to acknowledge.

Fragments of pottery and a variety of rude implements, as also copper kettles and other articles of European origin, have been found upon excavation within the enclosure and in its immediate vicinity. At *c* and *d*, skeletons have been disclosed by the plough. They were well preserved, and had been buried according to the Indian custom in a sitting posture.

The valley of the Mohawk in this vicinity, it is well known, was the favorite seat of the tribe whose name it bears, and has been made classical ground by the stirring incidents of our early history. It was here the Indians maintained themselves until the period of the Revolution, and it seems probable that it was they who erected the work in question at an earlier or later date in their history.* It corresponds in position and character with the works of the other parts of the State, and is precisely such a structure as we might expect to find erected by a very rude people. It could not be ascertained that there are any traditions connected with it; in fact, its existence is scarcely known beyond its immediate vicinity. The first intimation concerning it was derived from O. Morris, Esq., of the New York Institution for the Deaf and Dumb, to whom the author would convey his acknowledgments.

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* In the London Documents preserved in the Office of the Secretary of State is a paper containing the observations of Wentworth Greenhalgh, who in 1677 made a journey from Albany among the Indians to the westward. The following notices of the towns of the Maquaes, or Mohawks, are interesting in this connection:

"The Maquaes have four towns, viz.: Cahainaga, Canagora, Canajorha, Tionondogue, besides one small village about 110 miles from Albany.

"Cahainaga is double stockaded round; has four ports, about four foot wide apiece; conteyns about twenty-four houses; and is situate upon the edge of a hill, about a bow-shot from the river side.

"Canagora is only singly stockaded, has four ports like the other, contains about sixteen houses, and is situated upon a flat about a stone's throw from the water's edge.

"Canajorha is also singly stockaded, with like number of houses, and a similar situation, only about two miles distant from the water.

"Tionondogue is doubly stockaded round, has four ports, four foot wide apiece, contains about thirty houses, and is situated on a hill about a bow-shot from the river."—*Documentary History of New York*, Vol. I., p. 11.

CHAPTER III.

PALISADED ENCLOSURES.

Besides the earth-works which have already been described, and which furnish the principal objects of antiquarian interest in the State, occasional traces are found of defensive structures of a probably later date. These traces consist chiefly of a succession of small holes in the earth, caused by the decay of wooden palisades erected without the addition of an embankment and trench. These holes, which are never visible in cultivated grounds, enable us to follow the outlines and make out the forms of the structures which once existed where they are found. Some of these, as that of *Ganundesaga* near Geneva, are known to have been occupied within the historical period. And although it seems probable that the embankments of all the enclosures already described were originally crowned with palisades, still I have thought the difference between these and simple palisaded works sufficiently marked to constitute the basis of a classification. We may also premise what in the sequel will probably admit of no doubt in any mind, that these two classes of works are of different eras, though possessing a common origin.

PLATE XIII. No. 1.

"ANUNDESAGA CASTLE," NEAR GENEVA, ONTARIO COUNTY, NEW YORK.

The traces of this palisaded work are very distinct, and its outline may be followed with the greatest ease. Its preservation is entirely due to the circumstance that at the time of the cession of their lands at this point, the Senecas made it a special condition that this spot should never be brought under cultivation. "Here," said they, "sleep our fathers, and they cannot rest well if they hear the plough of the white man above them." The stipulations made by the purchasers have been religiously observed.

The site of this ancient palisade slopes gently towards a little stream, called Ganundesaga Creek, which supplied the occupants of the fort with water. The ground is covered with a close greensward, and some of the apple-trees planted by the Indians are still flourishing. In form the work was nearly rectangular, having

small bastions at the northwestern and southeastern angles. At *a* and *b* are small heaps of stone, bearing traces of exposure to fire, which are probably the remains of forges or fireplaces. The holes formed by the decay of the pickets are now about a foot deep. A fragment of one of the pickets was removed by Mr. L. H. Morgan, of Rochester, in 1847, and is now in the State Cabinet at Albany. It is of oak.

A few paces to the northward of the old fort is a low mound with a broad base, and undoubtedly of artificial origin. It is now about six feet high, and is covered with depressions marking the graves of the dead. There is a tradition current among the Indians concerning this mound, to the effect that here in the olden time was slain a powerful giant, above whom the earth was afterwards heaped. They believe that the bones of this giant may be found at the base. It would be interesting for a variety of reasons to have this mound excavated. By whatever people erected, it is certain that it was extensively used by the Senecas for purposes of burial.

In the cultivated fields surrounding the interesting works here described, numerous relics have been discovered—chiefly however of European origin.

This fort was destroyed by Sullivan in 1779. He burned the palisade, destroyed the crops in the adjoining fields, and cut down most of the fruit-trees which the Indians had planted.

PLATE XIII. No. 2.

PALISADED WORK OF THE SENECAS, SENECA TOWNSHIP, ONTARIO COUNTY, NEW YORK.

This work is situated about four miles to the northwest of that last described, upon a high ridge of land extending north and south, and parallel to and not far distant from another on which is situated an ancient earth-work figured on Plate VII. No. 1. A cross road from the "Castle Street Road" to the town of Vienna runs along the crown of the ridge, and longitudinally through the work under notice. Upon the right of this road the ground has been cultivated, and here the outlines of the work are obliterated. Traces of several *caches* which existed within the lines may however yet be seen. Upon the left, the forest still remains undisturbed; and here the outlines of the enclosure are quite distinct, yet not sufficiently marked to arrest the attention of the passer. The indications are precisely the same as in the work at Ganundesaga. Fragments of pottery, pipes, and other relics exactly corresponding with those which are so frequent in the earth-works described in a previous chapter, are also found in abundance upon this site. The work does not appear to have had bastions, and is probably of more ancient date than the one just noticed.

PLATE XIII. No. 3.

ANCIENT WORK OF THE CAYUGAS, LEDYARD TOWNSHIP, CAYUGA COUNTY, NEW YORK.

This work is found about twelve miles southwest of Auburn, in the town of Ledyard, Cayuga county. It forms a good illustration of the character of the aboriginal defences. It is situated upon a high point of ground, formed by the junction of two immense ravines, which here sink some hundreds of feet below the table-lands. A narrow spur, hardly wide enough to permit two to walk abreast, extends down to the bottom of the ravines, starting from the extreme point of the head-land. It is still called the "Indian Path," and affords a practicable descent to the water. At every other point the banks are almost if not entirely inaccessible. At some distance inward, extending from the bank of one ravine to the other, was originally a line of palisades. The holes left by their decay are still distinct, each about eight inches in diameter. The position is eminently a strong one, and, under the system of attack practised by the Indians, must have been impregnable. Within the enclosure are to be found *caches* and other features common to the class of works previously described, and with which this work entirely coincides, except that the embankment is wanting.

So far as could be ascertained, there is no tradition current respecting this work. Still, as it is known that the principal towns of the Cayugas existed in this vicinity until a very late date, there can be no doubt that this was one of their places of last resort. Very many traces of their former occupancy occur here and along the eastern shores of Cayuga Lake.

PLATE XIV. No. 1.

ANCIENT WORK OF THE SENECAS, NEAR VICTOR, ONTARIO COUNTY, NEW YORK.

The site occupied by the work here figured and the country adjacent, derives considerable interest from its historical associations. Recent investigations have satisfactorily determined that the Marquis De Nonville penetrated here in his celebrated expedition against the Senecas, in 1687; and there is good reason to believe that the traces at present existing are those of the palisaded fort which was destroyed at that time. They occupy the summit of a high hill, so steep upon most sides as to be ascended only with the greatest difficulty. The line of the

palisades can now be traced only at intervals; but from the nature of the ground and the recollection of persons familiar with the site before it was disturbed by the plough, it was found easy to restore with accuracy the parts which have been obliterated. The sole entrance which can now be made out is at the point marked by the letter *a*, where the palisades were carried for some distance inwards, leaving an open rectangular space, which may have been occupied by a block-house or something equivalent. Nearly in front, and at the bottom of a deep and narrow ravine, a copious spring starts out from the hill; probably the one alluded to by De Nonville in his letter of the 25th of August, 1687.

"On the next day," says this commander, "the 14th of July, we marched to one of the large villages of the Senecas, where we encamped. We found it burned and a fort quite nigh abandoned; it was very advantageously situated on a hill. * * * We remained at the four Seneca villages for ten days. All the time was spent in destroying the corn, which was in such great abundance that the loss, including the old corn which was in *cache* which we burnt, was computed at 400,000 minots (1,200,000 bushels) of Indian corn."

The large village alluded to here is no doubt the one which was situated on the eminence now known as "Boughton's Hill," where abundant traces of Indian occupancy at this period are found. These consist of copper kettles, French hatchets, broken gun-barrels, arrow-heads, pipes, pottery, burnt corn, etc. The iron recovered here at the time of the first settlement of the country, was sufficiently abundant to repay the cost of clearing the grounds. Indeed it was the source whence the early blacksmiths, for a long distance round, derived the iron for ordinary consumption; and even now the smithies in the vicinity consume large quantities of the metal which the operations of agriculture continue to bring to light.

The remains upon Boughton's Hill are mentioned by Mr. Clinton as corresponding in all respects with those which he observed in Onondaga county, and to which he was disposed to ascribe a high antiquity. They may all be referred to the same period, and no doubt mark the sites of Onondaga and Seneca villages in the 17th century.

PLATE XIV. No. 2.

ANCIENT WORK OF THE SENECAS, LIVONIA TOWNSHIP, LIVINGSTON COUNTY, NEW YORK.

THE traces of another palisaded work, no doubt erected by the Senecas, but probably at a later period than that near Victor, may still be seen on the farm of Gen. Adams, in Livonia township, Livingston county, two miles northeast of the village of Livonia.

It occupied a beautiful, broad swell of land, not commanded by any adjacent heights. Upon the west side of the lines is a fine, copious spring ; for which the Indians had constructed a large basin of loose stones. The form and dimensions of the work are given in the accompanying plan. Upon a little elevation to the left, as also in the forest to the northward, are extensive cemeteries. Many articles of comparatively late date are found in the graves. The area of the work was about ten acres.

Three miles to the eastward formerly existed the traces of a work represented to have been octangular in shape, and of considerable size. It has been wholly obliterated.

In Queen's county there were, some years ago, traces of aboriginal works, which seem to have differed very slightly from a portion of those just noticed. They are thus described by Judge Samuel Jones, in a notice of the local history of Oyster Bay, written in 1812:

"When this part of Long Island was first settled by the Europeans, they found two fortifications in the neighborhood of Oyster Bay, upon a neck of land ever since called, from that circumstance, 'Fort Neck.' One of them, the remains of which are very conspicuous, is on the southernmost point of land on the neck adjoining the Salt Meadow. It is nearly, if not exactly, a square; each side of which is about *one hundred feet* in length. The breastwork or parapet is of earth; and there is a ditch on the outside, which appears to have been about six feet wide. The other was on the southernmost point of the Salt Meadow, adjoining the bay, and consisted of palisades set in the ground. The tide has worn away the meadow where the fort stood, and the place is now part of the bay and covered with water; but my father has often told me that within his memory part of the palisades were still standing. In the bay, between the Salt Meadow and the beach, are two islands of marsh, called Squaw Islands; and the uniform tradition among the Indians is, that the forts were erected by their ancestors for defence against their enemies, and that upon the approach of a foe, they sent their women and children to these islands, which were in consequence called Squaw Islands."*

Examples of this class of aboriginal remains might be greatly multiplied. Those, however, which have already been presented, will serve sufficiently to illustrate their character. In all are found relics corresponding in every particular with those discovered within the walls of the earth-works described in the preceding chapter, but usually with the addition of articles of later date and known European origin. This circumstance is not without its importance in estimating the probable dependence between the two classes of remains.

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* Coll. N. Y. Hist. Soc., Vol. III., p. 338.

CHAPTER IV.

MOUNDS, BONE-HEAPS, ETC.

Various references to mounds or tumuli, resembling those found in the Valley of the Mississippi, have been made in the preceding pages. These mounds are far from numerous, and hardly deserve a separate notice. It is nevertheless an interesting fact to know that isolated examples occur, in situations where it is clear no dependence exists between them and the grand system of earth-works of the Western States. It serves to sustain the conclusion that the savage Indian tribes occasionally constructed mounds; which are however rather to be considered as accidents than the results of a general practice. The purposes of the mounds of New York, so far as can be determined, seem uniformly to have been those of sepulture. They generally occur upon commanding or remarkable positions. Most of them have been excavated, under the impulse of an idle curiosity, or have had their contents scattered by "money-diggers," a ghostly race, of which, singularly enough, even at this day, representatives may be found in almost every village. I was fortunate enough to discover one upon Tonawanda Island, in Niagara River, which had escaped their midnight attentions. It was originally about fifteen feet in height. At the base appeared to have been a circle of stones, perhaps ten feet in diameter, within which were several small heaps of bones, each comprising three or four skeletons. The bones are of individuals of all ages, and had evidently been deposited after the removal of the flesh. Traces of fire were to be discovered upon the stones. Some chippings of flint and broken arrow-points, as also some fragments of deers' horns, which appeared to have been worked into form, were found amongst the bones. The skulls had been crushed by the superincumbent earth.

The mounds which formerly existed in Erie, Genesee, Monroe, Livingston, St. Lawrence, Oswego, Chenango, and Delaware counties, all appear to have contained human bones, in greater or less quantities, deposited promiscuously, and embracing the skeletons of individuals of all ages and both sexes. They probably all owe their origin to a practice common to many of the North American tribes, of collecting together at fixed intervals the bones of their dead, and finally depositing them with many and solemn ceremonies. They were sometimes heaped together so as to constitute mounds; at others placed in pits or trenches dug in the earth; and it is probable they were in some instances buried in separate graves, but in long ranges, or deposited in caverns, either promiscuously or with regularity.

The period when this second burial took place occurred at different intervals

amongst the different tribes, but was universally denominated the "Festival of the Dead." Bartram, speaking of the burial customs of the Floridian Indians, says: "After the bone-house is full, a general solemn funeral takes place. The nearest kindred and friends of the deceased, on a day appointed, repair to the bone-house, take up the respective coffins, and, following one another in the order of seniority, the nearest relations and connections attending their respective corpses, and the multitude succeeding them, singing and lamenting alternately, slowly proceed to the place of general interment, when they place the coffins in order forming a pyramid. Lastly, they cover all over with earth, which raises a conical hill or mount. They then return to town in order of solemn procession, concluding the day with a festival which is called the 'Feast of the Dead.'"* The author here quoted adds in a note, that it was the opinion of some ingenious men with whom he had conversed, "that all those artificial pyramidal hills, usually called 'Indian Mounts,' were raised on such occasions, and are generally sepulchres;" from which opinion he takes occasion to dissent. There is no doubt a wide difference between the mounds thus formed and the great bulk of those connected with the vast ancient enclosures of the Western States.

The large cemeteries which have been discovered in Tennessee, Kentucky, Missouri, and Ohio, seem to have resulted from a similar practice. In these the skeletons were generally packed in rude coffins composed of flat stones, placed in ranges of great extent. The circumstance that many of these coffins were not more than two or three feet in length, gave rise to the notion of the former existence here of a pigmy race. The discovery of iron and some articles of European origin in one of these cemeteries in the vicinity of Augusta, Kentucky, shows that this mode of burial existed at a late period among the Indians in that direction.

The "bone-pits" which occur in some parts of Western New York, Canada, Michigan, etc., have unquestionably a corresponding origin. Several of these have been described in a previous chapter. They are of various sizes, but usually contain a large number of skeletons. In a few instances the bones appear to have been arranged with some degree of regularity.

One of these pits discovered some years ago, in the town of Cambria, Niagara county, was estimated to contain the bones of several thousand individuals. Another which I visited in the town of Clarence, Erie county, contained not less than four hundred skeletons. A deposit of bones comprising a large number of skeletons was found not long since, in making some excavations in the town of Black Rock, situated on Niagara River, in Erie county. They were arranged in a circle, with their heads radiating from a large copper kettle, which had been placed in the centre, and filled with bones. Various implements both of modern and remote date had been placed beside the skeletons.

In Canada similar deposits are frequent. Accounts of their discovery and character have appeared in various English publications, among which may be named the "British Colonial Newspaper," of September 24th, 1847, and the

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* Travels, p. 514.

"Edinburgh New Philosophical Journal," for July, 1848. From a communication in the latter, by Edward W. Bawtree, M. D., the subjoined interesting facts are derived.

A quantity of human bones was found in one spot, in 1846, near Barrie, and also a pit containing human bones near St. Vincent's. Great numbers were found in the latter, with several copper and brass kettles, and various trinkets and ornaments in common use among the Indians. This discovery led to the examination of a similar pit, about seven miles from Penetanqueshene, in the township of Giny. "This pit was accidentally noticed by a Canadian while making sugar in the neighborhood. He was struck by its appearance and the peculiar sound produced at the bottom by stamping there; and, in turning up a few spadefuls of earth, was surprised to find a quantity of human bones. It was more accurately examined in September, 1847, and found to contain, besides a great number of human skeletons, of both sexes and all ages, twenty-six copper and brass kettles and boilers; three large conch-shells; pieces of beaver-skin in tolerable preservation; a fragment of a pipe; a large iron axe, evidently of French manufacture; some human hair (that of a woman); a copper bracelet; and a quantity of flat auricular beads, perforated through the centre.

"The form of the pit is circular, with an elevated margin; it is about fifteen feet in diameter, and before it was opened was probably nine feet deep from the level of its margin to its centre and bottom; it was, in one word, funnel-shaped. It is situated on the top of a gentle rise, with a shallow ravine on the east side, through which, at certain seasons, runs a small stream. The soil is light, free from stones, and dry. A small iron-wood tree, about two inches in diameter, is growing in the centre of the pit.

"The kettles in the pit were found ranged at the bottom, resting on pieces of bark, and filled with bones. They had evidently been covered with beaver-skins. The shells and the axe were found in the intervals between the kettles. The beads were in the kettles among the bones, generally in bunches of strings.

Fig. 4.

"The kettles, of which Fig. 4 is an example, resemble those in use at the present day, and appear to be formed of sheet copper, the rim being beaten out so as to cover an iron band which passes around the mouth of the vessel. The iron handle by which they were suspended hooks into eyes attached to the band above mentioned. The smallest holds about six gallons; the largest not far from sixteen gallons. The copper is generally very well preserved; the iron, however, is much corroded. Two of the kettles were of brass.

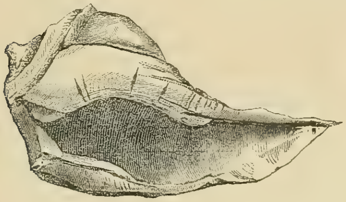

Fig. 5.

"The largest of the conch-shells, Fig. 5, weighs three pounds and a quarter, and measures fourteen inches in its longest diameter. Its outer surface has lost its polish, and is quite honey-combed by age and decomposition; the inside still retains its smooth lamellated surface. It

has lost its color, and appears like chalk. A piece had been cut from its base, probably for making the beads that were found in it.* From the base of the columella of the smallest shell a piece had been cut, evidently for the purpose of manufacturing beads. The extreme point of the base of each shell had a perforation through it.


Fig. 6.

"The axe, Fig. 6, is of nearly the same model with the tomahawk now in use among the Chippeway Indians, though very much larger, measuring eleven inches in length and six inches and a half along its cutting edge. Numbers of these have been found in the neighborhood on newly cleared land.

"The pipe is imperfect. It is made of the earthenware of which so many specimens are found in the neighborhood, in the form of vessels and pipes. The spots where the manufacture of these articles was carried on are still to be seen in some places.

"The beads are formed of a white chalky substance, varying in degree of density and hardness; they are accurately circular, with a circular perforation in the centre; of different sizes, from a quarter to half an inch, or rather more, in diameter; but nearly all of the same thickness, not quite the eighth of an inch. They may be compared to a peppermint lozenge with a hole through the centre. They were found in bunches or strings, and a good many were still closely strung on a fibrous woody substance. The bracelet is a simple band of copper, an inch and a half broad, closely fitting the wrist. The hair is long, evidently that of a woman, and quite fresh in appearance.

"Another pit, about two miles from that just noticed, was also examined in September. It is considerably smaller, being not more than nine feet in diameter, by about the same original depth. It is situated on rising ground, in a light sandy soil, and there is nothing remarkable in its position. A beech-tree, six inches thick, grew from its centre. It contained about as many skeletons as the other pit, but had no kettles in it. The bones were of individuals of both sexes and of all ages. Among them were a few fœtal bones. Many of the skulls bore marks of violence, leading to the belief that they were broken before burial. One was pierced by a round hole, like that produced by a musket ball. A single piece of a brass vessel was found in the pit; it had been packed in furs. A large number of shell beads, of various sizes, were also found here. Besides these, there were some cylindrical pieces of earthenware and porcelain or glass tubes, from an eighth to a quarter of an inch in diameter, and from a quarter to two inches long.† The former had the appearance of red and white tobacco-pipes, worn away by friction, the latter of red and white glass. A hexagonal body, with flat ends, about an inch and a half in diameter, and an inch thick, was also found. It was composed of some kind of porcelain, of hard texture, nearly vitreous, and much variegated in color, with alternate layers of red, blue, and white. It was perforated through the centre.

* Dr. Bern W. Budd, of New York, states that this shell, the *pyrula perversa*, abounds in the Gulf of Mexico and particularly in Mobile Bay. It has also been found by the officers of the U. S. Coast Survey as far north as Cape Fear, in North Carolina.

† These were clearly the European imitations of the much prized Indian *wampum*.

"The third of these pits was examined in November, 1847. It is situated in the township of Oro, on elevated ground. The soil is a light sandy loam. It measures about fifteen feet in diameter, has the distinctly defined elevated ring, but the centre less depressed than in those before examined, which may have resulted from the greater bulk of its contents. On its margin grew formerly a large pine, the roots of which had penetrated through the pit in every direction. The bones, which were of all sizes, were scarcely covered with earth. The skeletons amounted to several hundreds in number, and were well preserved. On some, pieces of tendon still remained, and the joints of the small bones in some cases were unseparated. Some of the skulls bore marks of violence.

"As in the first noticed pit, so in this, were found twenty-six kettles—four of brass and the rest of copper, one conch-shell, one iron axe, and a number of the flat perforated shell beads. The kettles were arranged in the form of a cross through the centre of the pit, and in a row around the circumference. The points of this cross seem to have corresponded with the cardinal points of the compass. All except two of the kettles were placed with their mouths downwards. The shell was found under one of the kettles, which had been packed with beaver-skins and bark. The kettles were very well preserved, but had all been rendered useless by blows from a tomahawk. The holes were broken in the bases of the vessels. Should any doubt exist as to the purposes of these pits, the fact that the kettles were thus rendered unserviceable would tend to increase that doubt, as it appears to have been a proceeding so very contrary to the habits and ideas of the Indians in general.*

"A pipe was found in this pit, described as having been composed of blue limestone or hard clay. On one side it had a human face, the eyes of which were formed of white pearly beads. An iron axe and sundry beads were also found here.

"A fourth pit was opened in December, 1847. It is situated on a gentle slope, in the second concession west of the Penetanqueshene road, in the township of Giny. In size it corresponds very nearly with the two first described, and probably contained about the same number of skeletons. In it were found sixteen conch-shells; a stone and clay pipe; a number of copper bracelets and ear ornaments; eleven beads of red pipe-stone; copper arrow-heads; a cup of iron resembling an old iron ladle; beads of several kinds, and various fragments of furs. The shells were arranged around the bottom of the pit, not in a regular row, but in threes and fours; the other articles were found mixed with the bones. The bones were of all sizes, and the skulls uninjured except by time. The accompanying sketch (Fig. 7) will sufficiently indicate the character of the pipes. The arrow-heads, as they are supposed to have been, were simple folds of sheet copper, resembling a roughly-formed ferule to a walking-stick. Besides the flat circular beads, which were found

Fig. 7.

* Dr. Bawtree is mistaken in supposing this practice uncommon. The Oregon Indians invariably render useless every article deposited with their dead, so as to remove any temptation to a desecration of the grave which might otherwise exist. A similar practice prevailed among the Floridian Indians.

in great numbers, were a few cylindrical porcelain beads, etc. The red-stone beads were five eighths of an inch broad, and three eighths thick, with small holes at one end, uniting with each other.

" There is reason to believe that the above constitute but a very small proportion of the pits that may be found in this neighborhood. The French Canadians, now that their attention has been directed to the subject, say that they are of frequent occurrence in the woods. But besides these larger and more evident excavations, smaller ones of the same shape and apparent character are often met with. They are usually called 'potato-pits.' So far as they have been examined, they do not contain deposits. Some appear to have been covered with bark at the bottom. One was examined in which were found some pieces of pottery and one or two human bones mixed with stones and black mould; which seemed to strengthen the supposition previously formed, that they were Indian graves from which the bones had been removed for interment in the large pits.

" A fifth pit has also been examined. It occurs about eight miles from Penetanqueshene, near the centre of the town of Giny. Close by its side is another pit, which is not circular but elongated, with a mound on each side. At the brow of the hill, if it may be so called, and commencing about twenty yards from the pits, there is the appearance of a long ditch extending in a southwestern direction; another ditch about half the length of this meets it at right angles on the top of the rising ground, and is continued a few yards beyond the point of junction; a third ditch intersects the short one, as shown in the following plan.

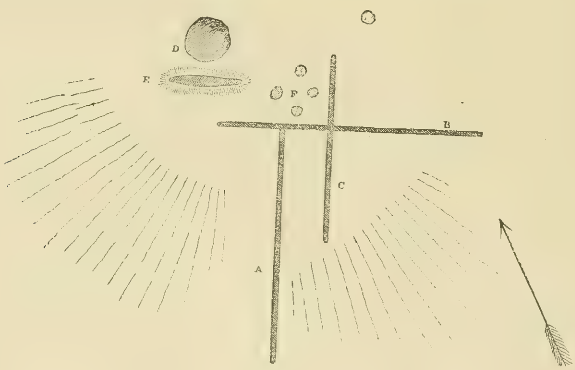

Fig. 8.

" The two first ditches form two sides of a parallelogram; but there is no sign of an enclosure at the other sides, where the ground is low and nearly level. The long ditch is seventy-five paces in length, the other half that length. The first terminates at a moderate sized gum-tree, the latter at the foot of a large birch. These ditches appear to be a succession of small pits or graves, and have an average depth of from one to two feet. Excavation disclosed no bones. Upon the north side of the shorter and upper ditch, several Indian graves were found,

not placed in any order, but scattered around at various distances apart. Three of these were examined and found to contain human bones. In one was an entire skeleton. No implements or ornaments accompanied the bones.

"The bones in the large pits were covered with three or four feet of earth, which is more than is usually found over them, and the marginal ring was in consequence less apparent. It contained very few relics besides the bones, which, from their decayed condition, seemed to indicate that burials here were made at a very remote period."

In Isle Ronde, situated near the extremity of Lake Huron, is a burial-place of the aborigines corresponding generally with those just described. It was visited in 1843 by Mr. Schoolcraft, who states that the human remains appeared to have been gathered from their original place of sepulture and finally deposited here. The bones were all arranged longitudinally, from north to south, in a wide grave or trench. There is upon the same island an Indian cemetery of comparatively modern date, in which the interments were made in the ordinary way. Another similar burial-place was visited by Mr. Schoolcraft, in the town of Hamilton, seventeen miles west of the head of Lake Ontario. The burials had been made on a high, dry ridge, in long trenches and rude vaults; the bones being piled upon each other longitudinally as at Isle Ronde. The trenches extend over the entire ridge; and one of these examined by Mr. Schoolcraft was estimated to include not less than fifteen hundred square feet. Various remains of art, pipes, shells, beads, etc., were found with the bones, and among them several brass kettles, in one of which were five infant skulls.

The origin of the various cemeteries above noticed admits of no doubt. The same practice which Bartram described as existing among the Floridians, and which we have reason to believe prevailed among the Indians of Tennessee, Kentucky, etc., also existed in a slightly modified form among the more northern tribes. They, too, had their solemn "Festival of the Dead," which is minutely described by Charlevoix, Brabeuf, Creuxius, and other early writers. Says Charlevoix: "This grand ceremony, the most curious and celebrated of all connected with the Indian religion, took place every eight years among some of the tribes, every ten years among the Hurons and the *Iroquois*. It was called the '*Fête des Morts*,' Festival of the Dead, or '*Festin des Ames*.'

"It commenced by the appointment of a place where they should meet. They then chose a president of the feast, whose duty it was to arrange every thing and send invitations to the neighboring villages. The appointed day arrived, all the Indians assembled and went in procession, two and two, to the cemetery. Among some tribes of stationary habits, the cemetery was a regular burial-ground outside the village. Some buried their dead at the foot of a tree, and others suspended them on scaffolds to dry; this last was a common proceeding among them when absent from home on a hunting expedition, so that on their return they might more conveniently carry the body with them.

"Arrived at the cemetery, they proceeded to search for the bodies; they then waited for some time to consider in silence a spectacle so capable of furnishing serious reflections. The women first interrupted the silence by cries of lamenta-

tion, which increased the feeling of grief with which each person seemed overcome. They then used to take the bodies, arrange the separate and dry bones, and place them in packets to carry on their shoulders. If any of the bodies were not entirely decomposed, they separated the flesh, washed the bones, and wrapped them in new beaver-skins. They then returned in the same procession in which they came, and each deposited his burden in his cabin. During the procession the women continued their lamentations, and the men testified the same marks of grief as on the death of the person whose bones they bore. This was followed by a feast in each house, in honor of the dead of the family. The succeeding days were considered as public days, and were spent in dancing, games, and combats, at which prizes were bestowed. From time to time they uttered certain cries, which were called '*les cris des âmes*.'

"They made presents to strangers, and received presents from them on behalf of the dead. These strangers sometimes came a hundred and fifty leagues. They also took advantage of these occasions to treat on public affairs or select a chief. Every thing passed with order, decency, and moderation; and every one seemed overcome with sentiments suitable to the occasion. Even the songs and dances expressed grief in some way. After some days thus spent, all went in procession to a grand council-room fitted for the occasion. They then suspended the bones and bodies in the same state as they had taken them from the cemetery, and placed there the presents intended for the dead. If among the skeletons there happened to be one of a chief, his successor gave a grand feast in his name. In some cases the bodies were paraded from village to village, and every where received with great demonstrations of grief and tenderness, and every where presents were made to them. They then took them to the spot designated as their final resting-place. All their ceremonies were accompanied with music, both instrumental and vocal, to which each marched in cadence.

"The last and common place of burial was a large pit, which was lined with the finest skins and any thing which they considered valuable. The presents destined for the dead were placed on one side; and when the procession arrived, each family arranged itself on a sort of scaffold around the pit; and as soon as the bodies were deposited, the women began again to cry and lament. Then all the assistants descended into the pit, and each person took a handful of earth, which he carefully preserved, supposing it would serve to give them success in their undertakings. The bodies and bones were arranged in order, and covered with furs and bark, over which were placed stones, wood, and earth. Each person then returned to his home, but the women used to go back from day to day with some *sagamatie* (pounded parched corn)."*

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* Charlevoix, Vol. II., p. 194, ubi supra; Creuxii Historia Canadensis, p. 97.

CHAPTER V.

IMPLEMENTS, ORNAMENTS, ETC.

Most of the minor relics of art discovered in the State of New York are such as are known to have been common amongst the Iroquois and other tribes which once occupied its territories. The character of these is so well known as to render unnecessary any detailed notice of the various articles obtained in the course of the explorations here recorded. A brief reference to the more remarkable specimens is therefore all which will be attempted.

Upon the site of every Indian town, as also within all of the ancient enclosures, fragments of pottery occur in great abundance. It is rare, however, that any entire vessels are recovered. Those which have been found, are for the most part, gourd-shaped, with round bottoms, and having little protuberances near the rim, or oftener a deep groove, whereby they could be suspended. A few cases have been known in which this form was modified, and the bottoms made sufficiently flat to sustain the vessel in an upright position. Fragments found in Jefferson county seem to indicate that occasionally the vessels were moulded in forms nearly square, but with rounded angles. The usual size was from one to four quarts; but some must have contained not less than twelve or fourteen quarts. In general there was no attempt at ornament; but sometimes the exteriors of the pots and vases were elaborately if not tastefully ornamented with dots and lines, which seem to have been formed in a very rude manner with a pointed stick or sharpened bone. Bones which appear to have been adapted for this purpose are often found. After the commencement of European intercourse, kettles and vessels of iron, copper, brass, and tin, quickly superseded the productions of the primitive potter, whose art at once fell into disuse. Pipes and various articles of clay, which may be denominated *terra cottas*, continued, nevertheless, to be made. The pipes of native manufacture were preferred, as they still are, to those of European or American production. After the introduction of tools, and as soon as the Indians became acquainted with foreign models, great improvement was made in their manufacture. The following examples will furnish very good illustrations of the forms of the Indian pipe.

Fig. 9 was found within an enclosure in Jefferson county, Plate IV. No. 4. It is engraved one half the size of the original. It is of fine red clay, smoothly moulded, and two serpents rudely imitated are represented coiling around the bowl. Bushels of fragments of pipes have been found within the same enclosure. Some appear to have been worked in the form of the human head, others in representations of animals, and others still in a variety of regular forms.

Fig. 10 was found within another enclosure in the same county. It differs from the first only in respect of size.

Fig. 11 was found on the site of an old Seneca town, in the town of Livonia, Livingston county. It resembles the other in shape, but is of darker color, and not so well burned. The difference to be observed between it and the others may be ascribed entirely to the difference in the clay composing it.

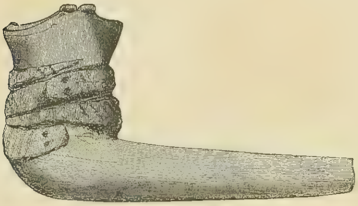

Fig. 9.

Fig. 10.

Fig. 11.

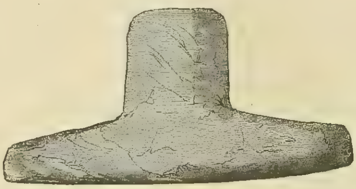

Fig. 12.

Fig. 12. This is a greatly reduced representation of an article of stone found near Mount Morris, in Livingston county, and now in the New York State Cabinet at Albany. It is composed of "soap stone," and in shape corresponds generally with the pipes of stone found in the mounds of the Mississippi Valley. If intended for a pipe, which seems most likely, it was never finished, as the cavity of the bowl is merely indicated. One or two pipes of stone of very nearly the same shape have been found in this vicinity, but in point of symmetry or finish they are in no way comparable to those of the mounds.

Some pipes of precisely the same material, and of identical workmanship with those found in the ancient enclosures, have been discovered in modern Indian graves, in Cayuga county. One of these, in the form of a bird, and having eyes made of silver inserted in the head, is now in possession of the author. Various articles of European or American manufacture were found in the same grave.

The most beautiful *terra cotta* which I found in the State, and which in point of accuracy and delicacy of finish is unsurpassed by any similar article which I have seen of aboriginal origin, is the head of a fox, of which Fig. 13 is a full-size engraving. The engraving fails in conveying the spirit of the original, which is composed of fine clay, slightly burned. It seems to have been once attached to a body, or perhaps to a vessel of some kind. It closely resembles some of the

terra cottas from the mounds of the West and Southwest. It was found upon the site of an ancient enclosure in Jefferson county, in the town of Ellisburgh, near the beautiful village of Pierrepont Manor.

Fig. 13.

Fig. 14.

Fig. 15.

Figs. 14 and 15 were found upon the site of an abandoned Seneca village, in the town of Mendon, Monroe county. The spot is now known as the "Ball Farm," and is remarkable for the number and variety of its ancient relics. Vast quantities of these have been removed from time to time. Some of the miniature representations of animals found here are remarkable for their accuracy.

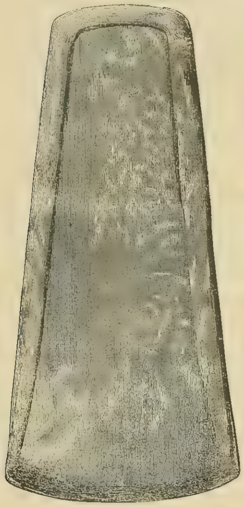

Fig. 16.

The stone axe or hatchet may be found from Cape Horn to Baffin's Bay. Specimens taken from the intervening localities can be distinguished from each other only by the difference of the materials of which they are composed. I have found them in Nicaragua precisely resembling those of New York. Little, therefore, need be said concerning them. Fig. 16 was obtained in the vicinity of an ancient work on the Susquehanna River, in Pennsylvania, near the New York State line. It is remarkable for its symmetry and size, and also for the manner in which it is hollowed upon the inner side. This last named feature is well indicated in the engraving.

Figs. 17 and 18 present a front and reverse view of a very fine stone axe, found in Livingston county, near Avon Springs. The material is of intense hardness,

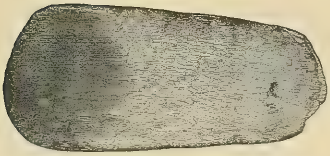

Fig. 17.

Fig. 18.

resembling porphyry. It is, nevertheless, worked with mathematical accuracy, and highly polished. The edge is very sharp. It is as fine a specimen of the Indian stone axe as ever fell under my notice.

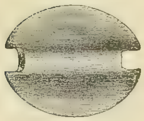

Fig. 19.

Fig. 19 is of a greenish colored slate, and resembles a kind of ornamental hatchet, made of delicate material, which is found at the South and West. It was obtained near Springport, Cayuga county. For examples of similar articles, the reader is referred to the first volume of the Smithsonian Contributions to Knowledge, p. 218.

One of the most interesting relics which has yet been discovered in the State is an axe of *cast copper*, of which Fig. 20 is a reduced engraving. The original is four inches long by two and a half broad on the edge, and corresponds in shape with some of those of wrought native copper, which have been found in the mounds of Ohio. From the granulations of the surface, it appears to have been cast in sand. There is no evidence of its having been used for any purpose. Its history, beyond that it was ploughed up somewhere in the vicinity of Auburn, Cayuga county, is unknown. No opportunity has yet been afforded of analyzing any portion, so as to determine whether it has an intermixture of other metals. It appears to be pure copper. An inspection serves to satisfy the inquirer that it is of aboriginal origin; but the questions when and by whom made, are beyond our ability to answer. There is no evidence that the mound-builders understood the smelting of metals; on the contrary, there is every reason to believe that they obtained their entire supply in a native state, and worked it cold. The Portuguese chronicler of Soto's Expedition into Florida, mentions copper hatchets, and rather vaguely refers to a "smelting of copper," in a country which he did not visit, far to the northward, called "Chisca." The Mexicans and Peruvians made hatchets of copper alloyed with tin. It would seem that this hatchet was obtained from that direction, or made by some Indian artisan after intercourse with the whites had instructed him in the art of working metals. At present it is prudent to say that the discovery of this relic is an anomalous fact, which investigators should only bear in mind, without venturing to make it the basis of deductions or inferences of any kind.

Fig. 20.

Fig. 21.

Fig. 21 is an example of the iron axe introduced among the Indians by the French. Thousands of these are found in the western counties of the State.

Figs. 22, 23, and 24 are selected by the author from the collection of relics made in the progress of these explorations, from their resemblance to relics of common occurrence in the mounds of the Mississippi Valley. Fig. 22 is almost identical in shape and material with some of the articles from the mounds, described on page 237 of the first volume of these Contributions. The same may

be observed of Fig. 23. The material is the green, variegated slate, of which so many of the above named relics are composed. The first mound was found near Scottsville, Wheatland township, Monroe county; the second, near Springport, Cayuga

FIG. 22.

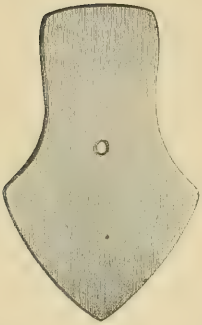

FIG. 23.

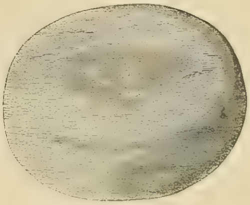

FIG. 24.

county. Near this place also was found the disk, Fig. 24. It is of green slate, and corresponds entirely with those described on page 221 of the same volume with the preceding.

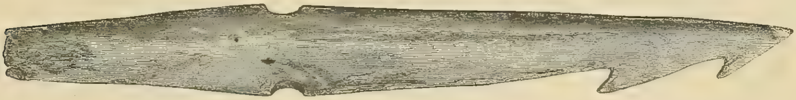

FIG. 25.

FIG. 26.

FIG. 27.

Fig. 25 is the point of a fish-spear, made of the ulna of the deer; found in Livingston county. Figs. 26 and 27 are of the same material, and were used as bodkins or for working clay; found in Jefferson county.

Besides these relics, quantities of beads of stone, bone, and shell, ornaments of many kinds and of various materials, as also implements of aboriginal, or European, or American fabric, are found all over the State, but in more abundance in

the western counties. They are not of sufficient importance to merit a detailed notice, and are chiefly interesting as the relics of a race fast disappearing, and whose existence will soon be known to history alone. It is to be hoped that, however insignificant they may seem, they may be carefully preserved and treasured for public inspection, in places or institutions designated for the purpose.

CHAPTER VI.

CONCLUDING OBSERVATIONS.

By whom were the aboriginal monuments of Western New York erected, and to what era may they be ascribed? The consideration of these questions has given rise to a vast amount of speculation, generally not of the most philosophical, nor yet of the most profitable kind. If the results arrived at have been erroneous, unsatisfactory, or extravagant, it may be ascribed to the circumstance that the facts heretofore collected have been too few in number and too poorly authenticated to admit of correct conclusions, not less than to the influence of preconceived notions, and to that constant leaning towards the marvellous, which is a radical defect of many minds. Rigid criticism is especially indispensable in archæological investigations; yet there is no department of human research in which so wide a range has been given to conjecture. Men seem to have indulged the belief that here nothing is fixed, nothing certain, and have turned aside into this field as one where the severer rules which elsewhere regulate philosophical research are not enforced, and where every species of extravagance may be indulged in with impunity. I might adduce numberless illustrations of this remark. The Indian who wrought the rude outlines upon the rock at Dighton, little dreamed that his work would ultimately come to be regarded as affording indubitable evidence of Hebrew, Phœnician, and Scandinavian adventure and colonization in America; and the builders of the rude defences of Western New York, as little suspected that Celt and Tartar, and even the apochryphal Madoc with his "ten ships," would, in this the nineteenth century of our faith, be vigorously invoked to yield paternity to their labors!

The probable purposes to which these works were applied are perhaps sufficiently evident from what has already been presented. Their positions, general close proximity to water, and other circumstances not less conclusive, imply a defensive origin. The unequivocal traces of long occupancy found within many of them, would further imply that they were fortified towns and villages, and were permanently occupied. Some of the smaller ones, on the other hand, seem rather designed for temporary protection,—the citadels in which the builders sought safety for their old men, women, and children, in case of alarm or attack.

In respect to date nothing positive can be affirmed. Many of them are now covered with heavy forests; a circumstance upon which too much importance has been laid, and which in itself may not necessarily be regarded as indicative of great age, for we may plausibly suppose that it was not essential to the purposes of the builders that the forests should be removed. Still I have seen trees from

one to three feet in diameter standing upon the embankments and in the trenches; which would certainly carry back the date of their construction several hundred years, perhaps beyond the period of the discovery in the fifteenth century. There is nothing, however, in this circumstance, nor in any other bearing upon the subject, which would necessarily imply that they were built by tribes anterior to those found in occupation of the country by the whites. And this brings us at once to the most interesting point of our inquiry, viz: *By whom were these works erected?*

I have already mentioned that within them are found many relics of art and many traces of occupancy. These, I had ample opportunities of ascertaining in the course of my investigations, are absolutely *identical* with those which mark the sites of towns and forts known to have been occupied by the Indians, within the historical period. The pottery taken from these sites and from within the supposed ancient enclosures, is alike in all respects; the pipes and ornaments are undistinguishable; and the indications of aboriginal dwellings are precisely similar, and, so far as can be discovered, have equal claim to antiquity. Near many of these works are found cemeteries, in which well-preserved skeletons are contained, and which, except in the absence of remains of European art, differ in no essential respect from the cemeteries found in connection with the abandoned modern towns and "castles" of the Indians. There are other not less important facts and coincidences, all of which go to establish that if the earth-works of Western New York are of a remote ancient date, they were not only *secondarily* but *generally* occupied by the Iroquois or neighboring and contemporary nations; or else—and this hypothesis is most consistent and reasonable—they were erected by them.

The questions by whom were the aboriginal monuments of Western New York erected, and to what era may they be ascribed, have probably been answered to the satisfaction of every mind by the simple detail of facts in the preceding chapters.

It may be objected that if the Indians constructed works of this kind, it could not have escaped the notice of the early explorers, and would have been made the subject of remark by them. The omission is singular, but not unaccountable. They all speak of the defences of the Indians as composed of palisades firmly set in the ground. The simple circumstance of the earth being heaped up around them, to lend them greater firmness, may have been regarded as so natural and simple an expedient, as not to be deserving of special mention, particularly as the embankment, in such a case, would be an entirely subordinate part of the structure. After the introduction of European implements, enabling the Indians to plant their pickets more firmly in the ground, and to lend them a security before unattainable, the necessity for an embankment was in a great degree obviated. We may thus account for its absence in their later structures, which also underwent some modification of form, suggested by the example or instructions of the whites, or by the new modes of warfare following the introduction of fire-arms. Thus in the plan of the old Seneca fort of *Ganundasaga*, we find distinct traces of the bastion—a feature observable in none of the more ancient defences.

I am aware that the remnants of the Indian stock which still exist in the State, generally profess total ignorance of these works. I do not, however, attach much importance to this circumstance. When we consider the extreme likelihood of the forgetfulness of ancient practices, in the lapse of three hundred years, the lack of knowledge upon this point is the weakest of all negative evidence. Cusick, the Indian, in his so-called "History of the Six Nations," has, no doubt, correctly described the manner in which they constructed their early defences. "The manner of making a fort: First, they set fire against as many trees as it requires to make the enclosure, rubbing off the coals with their stone axes, so as to make them burn faster. When the tree falls, they put fires to it about three paces apart, and burn it into pieces. These pieces are then brought to the spot required, and set up around, according to the bigness of the fort. *The earth is then heaped on both sides.* The fort has generally two gates, one for passage and one to the water." "The people," continues Cusick, "had implements with which they made their bows and arrows. Their kettles were made of baked clay; their awls and needles of sharpened bones; their pipes of baked clay or soft stone; a small turtle-shell was used to peel the bark, and a small dry stick to make fire by boring it against seasoned wood."

Colden observes of their defences, as they were constructed in his time: "Their castles are generally a square surrounded with palisades, without any bastions or outworks; for, since the general peace, their villages all lie open."*

In full view of the facts before presented, I am driven to a conclusion little anticipated when I started upon my trip of exploration, that the earth-works of Western New York were erected by the Iroquois or their western neighbors, and do not possess an antiquity going very far back of the discovery. Their general occurrence upon a line parallel to and not far distant from the lakes, favors the hypothesis that they were built by frontier tribes—an hypothesis entirely conformable to aboriginal traditions. Here, according to these traditions, every foot of ground was contested between the Iroquois and the Gah-kwas and other western tribes; and here, as a consequence, where most exposed to attack, were permanent defences most necessary. It was not until after the Confederation, that the Five Nations were able to check and finally expel the warlike people which disputed with them the possession of the beautiful and fertile regions bordering the lakes; and it is not impossible that it was the pressure from this direction which led to that Confederation,—an anomaly in the history of the aborigines. Common danger, rather than a far-seeing policy, may be regarded as the impelling cause of the consolidation.

In conclusion, I may be permitted to observe, that the ancient remains of Western New York, except so far as they throw light upon the system of defence practised by the aboriginal inhabitants, and tend to show that they were to a degree fixed and agricultural in their habits, have slight bearing upon the grand ethnological

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* History of the Five Nations, Vol. I., p. 9.

and archæological questions involved in the ante-Columbian history of the continent. The resemblances which they bear to the defensive structures of other rude nations, in various parts of the world, are the result of natural causes, and cannot be taken to indicate either a close or remote connection or dependence. All primitive defences, being designed to resist common modes of attack, are essentially the same in their principles, and seldom differ very much in their details. The aboriginal hunter and the semi-civilized Aztec, selected precisely similar positions for their fortresses, and defended them upon the same general plan; yet it would be palpably unsafe to found conclusions as to the relations of the respective builders, upon the narrow basis of these resemblances alone.

APPENDIX.

ANCIENT WORKS IN PENNSYLVANIA AND NEW HAMPSHIRE.

Without the boundaries of the State of New York, there are works composed of earth, closely resembling those described in the preceding pages. Among these may be named the small earth-works of Northern Ohio, which the author himself was at one time led to believe constituted part of the grand system of the mound builders.* The more extensive and accurate information which he has now in his possession concerning them, as also concerning those of Western New York, has led to an entire modification of his views, and to the conviction that they are all of comparatively late date, and probably of common origin.

Some similar works are said to occur in Canada; but we have no account at all satisfactory concerning them. One is mentioned by Laing (*Polynesian Nations*, p. 109) upon the authority of a third person, as situated upon the summit of a precipitous ridge, near Lake Simcoe, and consisting of an embankment of earth, enclosing a considerable extent of ground. Mr. Schoolcraft also states that there are some ancient enigmatical walls of earth in the vicinity of Dundas, which extend several miles across the country, following the leading ridges of land. These are represented to be from five to eight miles in length, and not far from six feet high, with passages at intervals, as if for gates (*Oneota*, p. 326). Our knowledge concerning these is too limited to permit any conjecture as to their design.

In the State of Pennsylvania, there are some remains, which may be regarded as the "outliers" of those of New York. They are confined to the upper counties. Those in the Valley of Wyoming are best known. They have, however, been lately so much obliterated, that it is probable they can be no longer traced. One of the number was examined and measured in 1817 by a gentleman of Wyoming, whose account is published by Mr. Miner, in his "History of Wyoming."

"It is situated in the town of Kingston, Luzerne county, upon a level plain, on the north side of Toby's Creek, about one hundred and fifty feet from its bank, and about half a mile from its confluence with the Susquehanna. It is of an oval or elliptical form, having its longest diameter from northeast to southwest, at right angles to the creek. Its diameters are respectively 337 and 272 feet. On the southwest side appears to have been a gateway, twelve feet wide, opening towards the great eddy of the river into which the creek falls. It consisted of a single

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* Ancient Monuments of the Mississippi Valley.

embankment of earth, which in height and thickness appears to have been the same on all sides. Exterior to the wall is a ditch. The bank of the creek upon the side towards the work is high and steep. The water in the creek is ordinarily sufficiently deep to admit canoes to ascend to the fortification from the river. When the first settlers came to Wyoming, this plain was covered with its native forests, consisting principally of oak and yellow pine; and the trees which grew upon the work are said to have been as large as those in any part of the valley. One large oak, upon being cut down, was found to be 700 years old. The Indians have no traditions concerning these fortifications; nor do they appear to have any knowledge of the purposes for which they were erected."—(*Miner's History of Wyoming*, p. 25.) Traces of a similar work existed on "Jacob's Plains," on the upper flats of Wilkesbarre. "It occupied the highest point on the flats, which in the time of freshets appears like an island in the sea of waters. In size and shape it coincides with that already described. High trees were growing upon the embankment at the period of the first settlement of the country. It is about eighty rods from the river, towards which opened a gateway; and the old settlers concur in stating that a *well* [*cache?*] existed in the interior near the southern line. On the banks of the river is an ancient burial-place, in which the bodies were laid horizontally in regular rows. In excavating the canal through the bank bordering the flats, perhaps thirty rods south of the fort, another burial-place was disclosed, evidently more ancient, for the bones crumbled to pieces almost immediately upon exposure to the air, and the deposits were far more numerous than in that near the river. The number of skeletons are represented to have been countless, and the dead had been buried in a sitting posture. In this place of deposit no beads were found, while they were common in the other."—(*Miner's History*, p. 28.)

Near this locality, which seems to have been a favorite one with the Indians, medals bearing the head of the First George, and other relics of European origin, are often discovered.

Still further to the northwest, near the borders of New York, and forming an unbroken chain with the works of that State, are found other remains. One of these, on the Tioga River, near Athens, was ascribed by the Duke de Rochefoucauld to the French, in the time of De Nonville! He describes it as follows:

"Near the confines of Pennsylvania, a mountain rises from the banks of the River Tioga, in the shape of a sugar loaf, upon which are to be seen the remains of some entrenchments. These are called by the inhabitants the 'Spanish Ramparts,' but I judge that they were thrown up against the Indians, in the time of De Nonville. A breast-work is still remaining."—(*Travels in America.*) A similar work, circular or elliptical in outline, is said to exist in Lycoming county. Near it are extensive cemeteries.—(*Day's Hist. Coll.*, p. 455.)

In the New England States few traces of works of this kind are to be found. There are, however, some remains in the State of New Hampshire, which, whatever their origin, are entitled to notice. The subjoined plan of one of these is from a sketch made in 1822 by Jacob B. Moore, Esq., late Librarian of the Historical Society of New York, who has also furnished the accompanying description.

"According to your request, I send the enclosed sketch and memoranda of an ancient fortification, supposed to have been the work of the Penacook Indians, a once powerful tribe, whose chief seat was in the neighborhood of Concord, New Hampshire. The original name of the town was derived from that of the tribe. The last of the Penacooks long since disappeared, and with them have perished most of the memorials of their race. Enough has come down to us, however, in tradition, added to the brief notes of our historians, to show that the Penacooks were once a numerous, powerful, and warlike tribe. Gookin places them under the general division of the Pawtucketts, which he calls 'the fifth great sachemship of Indians.'* Under the name of Penacooks, were probably included all the Indians inhabiting the valley of the Merrimack, from the great falls at the Amoskeag to the Winnepiseogee Lake, and the great carrying-place on the Pemigewasset. That they were one and the same tribe, is rendered probable from the exact similarity of relics, which have been found at different places, and from the general resemblance of the remains of ancient fortifications, which have been traced near the lower falls of the Winnepiseogee, in Franklin and Sanbornton, and on the table-land known as the Sugar-Ball Plain, in Concord. Tradition ascribes to each the purpose of defence against a common enemy, the Maquaas or Mohawks of the west.

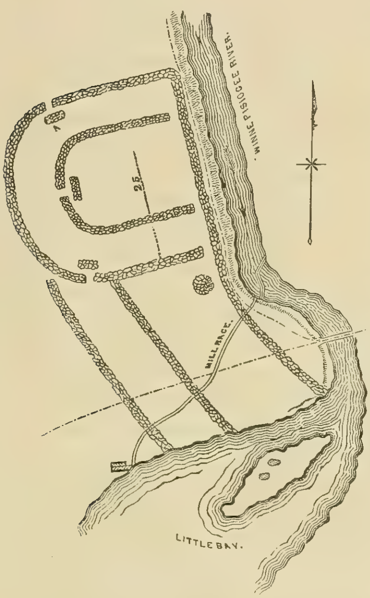

Fig. 28.

"The accompanying sketch was taken in pencil, on a visit to the spot, in company with the Hon. James Clark and several friends in the month of September, 1822. The remains are on the west side of the Winnepiseogee, near the head of Little Bay, in Sanbornton, New Hampshire. The traces of the walls were at that time easily discerned, although most of the stones had been removed to the mill-dam near at hand, on the river. On approaching the site, we called upon a gentleman (James Gibson) who had lived for many years near the spot, and of whom we learnt the following particulars: He had lived in Sanbornton fifty-two years, and had known the fort some time previous to settling in the place. When he came to the town to reside, the walls were two or three feet high, though in some places they had fallen down, and the whole had evidently much diminished in height, since the first erection. They were about three feet in thickness, con-

* Gookin, in I, Mass. Hist. Coll., I., 149.

structed of stones outwardly, and filled in with clay, shells, gravel, &c., from the bed of the river and shores of the bay. The stones of which the walls were constructed were of no great size, and such as men in a savage state would be supposed to use for such a purpose. They were placed together with much order and regularity, and when of their primitive height, the walls must have been very strong—at least, sufficiently strong for all the purposes of defence against an enemy to whom the use of fire-arms was unknown.

"The site of the fortification is nearly level, descending a little from the walls to the bank of the river. West, for the distance of nearly half a mile, the surface is quite even. In front or east, on the opposite side of the river, are high banks, upon which at that time stood a thick growth of wood. When the first settlers discovered the fort, there were oak trees of large size standing within the walls. Within the enclosure, and in the mound and vicinity, were found innumerable Indian ornaments, such as crystals cut into the rude shapes of diamonds, squares, pyramids, &c., with ornamental pipes of stone and clay,—coarse pottery ornamented with various figures,—arrow-heads, hatchets of stone, and other common implements of peace and war.

"The small island in the bay appears to have been a burial-place, from the great quantity of bones and other remains disclosed by the plough, when settlements were commenced by the whites. Before the island was cultivated, there were several large excavations, resembling cellars or walls discovered, for what purpose constructed or used, can of course only be conjectured. There is a tradition that the Penacooks, at the time of their destruction by the Maquaas, had three hundred birch canoes in Little Bay.

"After writing thus far, I addressed a note to the Hon. James Clark, of Franklin, New Hampshire, with inquiries as to the present state of these ruins. Mr. Clark was kind enough at once to make a special visit to the site of the ruins, in company with Mr. Bamford, son of one of the first settlers. The following is an extract from his reply:

"'The remains of the walls are in part plainly to be traced; but the ground since our former examination has been several years ploughed and cultivated, so as to now give a very indistinct view of what they were at our previous visit, when the foundation of the whole could be distinctly traced. No mounds or passage-ways can now be traced. A canal to convey water to a saw and grist mill occupies the place of the mound marked *m*. The stones used in these walls were obtained on the ground, and were of such size as one man could lift; they were laid as well as our good walls for fences in the north, and very regular; they were about three feet in thickness and breast high when first discovered. The stones have been used to fill in the dam now adjoining. There were no embankments in the interior. The distance between the outer and inner wall was about sixty feet; the distance from the north to the south wall was about 250 feet, and from the west wall to the river about 220 feet. There were two other walls extending south to Little Bay. The general elevation of the ground was about ten feet above, and gently sloping to the river bank, which is about five feet above the water of the river. The distance between Great Bay and Little Bay is about 160 rods, with a gradual fall of fifteen

feet. Here was a great fishing-place for the Indians.' Mr. Bamford states that he has heard his father and Mr. Gibson say, that on their first acquaintance with this place, they have seen three hundred bark canoes here at a time. This may have been in consequence of the number of bays and lakes near this place. Sanbornton was laid out and surveyed in 1750; but Canterbury, adjoining the bay, was settled as early as 1727.

"The remains of a fortification, apparently of similar construction to that above described, were some years since to be seen on the bluffs east of the Merrimack River, in Concord, on what was formerly known as Sugar-ball Plain. The walls could readily be traced for some distance, though crumbled nearly to the ground, and overgrown with large trees."*

CHARACTER OF INDIAN DEFENCES.

The fortifications of the savage or hunter tribes of North America are uniformly represented to have been constructed of rows of pickets, surrounding their villages, or enclosing positions naturally strong and easy of defence. The celebrated stronghold of the Narragansetts in Rhode Island, destroyed in 1676 by the New England colonists under Winthrop and Church, was an elevation of five or six acres in extent, situated in the centre of a swamp, and strongly defended by palisades. It was of extraordinary size, and enclosed not far from six hundred lodges.

Of like character was the fort of the Pequots, on the Mystic River, in Connecticut, destroyed by Captain Mason. According to Hackluyt, the towns of the Indians on the St. Lawrence were defended in a similar manner. The first voyagers describe the aboriginal town of Hochelaga, now Montreal, as circular in form, and surrounded by three lines of palisades. Through these there was but a single entrance, well secured by stakes and bars; and upon the inside of the defence, were stages or platforms, upon which were placed stones and other missiles, ready for use, in case of attack. The town contained about fifty lodges.—(*Hackluyt*, Vol. III., p. 220.)

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* "A mound 45 or 50 feet in diameter is situated on the northern shore of Ossipee Lake, New Hampshire. It is ten feet high, and was originally covered with timber. The earth is not like that of the meadow in which it stands, but of the adjacent plain. A slight excavation was made in it a number of years ago, in the course of which three entire skeletons were found, accompanied by two tomahawks and some coarse pottery. On the surrounding meadow were to be seen, when the ground was first cleared, the hills where the corn had anciently grown."—*Hist. and Mis. Coll. of N. H.*, Vol. II., p. 47: *New Hampshire Gazetteer*, p. 207.

Charlevoix observes, that "the Indians of Canada are more expert in erecting their fortifications than in building their houses." He represents that their villages were surrounded by double and frequently by triple rows of palisades, interwoven with branches of trees, and flanked by redoubts.—(*Canada*, Vol. II., p. 128.) Champlain also describes a number of fortified works on the St. Lawrence, above *Trois Rivières*, which "were composed of a number of posts set very close together." He also speaks of "forts which were great enclosures, with tiers joined together like pales," within which were the dwellings of the Indians.—(*Purchas*, Vol. IV., pp. 1612, 1644.) Says La Hontan, "their villages were fortified with double palisades of very hard wood, which were as thick as one's thigh, fifteen feet high, with little squares about the middle of the courtines (curtains).—(Vol. II., p. 6.) The Indians on the coasts of Virginia and North Carolina are described as possessing corresponding defences. "When they would be very safe," says Beverly, "they treble the pales."—(*Hist. Vir.*, p. 149. See also *Amidas* and *Barlow*, in *Pink.*, Vol. XII., p. 567; *Heriot*, *ib.* p. 603; *Lafitau*, Vol. III., p. 228, etc. etc.)

Among the Floridian tribes, the custom of fortifying their villages seems to have been more general than among the Indians of a higher latitude. This may readily be accounted for from the fact that they were more fixed in their habits, considerably devoted to agriculture, and less averse to labor than those of the north. The chronicler of Soto's Expedition speaks of their towns as defended by "strong works of the height of a lance," composed of "great stakes driven deep in the ground, with poles the bigness of one's arm placed crosswise, both inside and out, and fastened with pins to knit the whole together." Herrara, in his compiled account of the same expedition, has the following confirmation. "The town of Mabila or Mavila (Mobile) consisted of eighty houses seated in a plain, enclosed by piles driven down, with timbers athwart, rammed with long straw and earth between the hollow spaces, so that it looked like a wall smoothed with a trowel; and at every eighty paces was a tower, where eight men could fight, with many loop-holes and two gates. In the midst of the town was a large square."—(*Hist. America*, Vol. V., p. 324.) Du Pratz also gives a corresponding account of the defences of the Natchez and neighboring tribes. "Their forts are built circularly, of two rows of large logs of wood, the logs of the inner row being opposite to the joinings of those of the outer row. These logs are about fifteen feet long, five feet of which are sunk in the earth. The outer logs are about two feet thick, the inner ones half as much. At every forty paces along this wall, a circular tower juts out, and at the entrance of the fort, which is always next the river, the two ends of the wall pass beyond each other, leaving a side opening. In the middle of the fort stands a tree, with the branches lopped off within a short distance of the trunk, and this serves as a watch-tower.—(*Hist. Louisiana*, p. 375.) The subjoined description and illustrative engraving, copied from De Bry, no doubt convey a correct idea of the character of the Floridian defences.

"Solent Indi hac ratione sua oppida condere. Delecto aliquo loco secundum torrentis alicujus profluentem, eum quantum fieri potest complanant; deinde sulco in orbem ducto, crassos et rotundos palos duorum hominum altitudinis conjunctim

terræ infigunt, circa oppidi ingressum circulum nonnihil contrahendo cochleæ in morem, ut aditum angustiorem reddant, nec plures quam binos conjunctim admittentem, torrentis etiam alveo ad hunc aditum ducto; ad hujus aditus caput solet ædicula rotunda extrui, altera item ad ejus sinum, singulæ rimis et foraminibus plenæ, et eleganter pro regionis ratione constructæ. In his constituuntur vigiles viri illi, qui hostium vestigia è longinquo odorantur; nam simul atque aliquorum vestigia naribus perceperunt, adversus contendunt, et iis deprehensis clamorem attollunt, quo exaudito incolæ statim ad oppidi tutelam convolant; arcubus sagittis, et clavis armati. Oppidi meditullium occupant, Regis ædes nonnihil sub terram depressæ ob solis æstum; has cingunt, nobiliorum ædes, omnes palmæ ramis leviter tectæ, quia novem mensibus dumtaxat iis utuntun, tribus aliis mensibus, ut diximus, in sylvis degentes. Unde reduces, domos repetunt; sin eas ab hostibus incendio absumptas reperiunt, novas simili materia exstruunt, adeo magnifica sunt Indorum palatia."

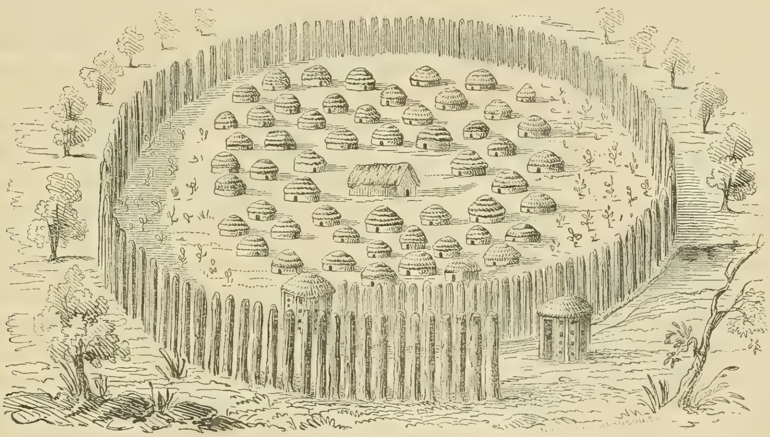

Fig. 29.

"The Indians build their towns in this wise. Having made choice of a spot near a running stream, they level it off as even as they can. They next draw a furrow of the size of the intended town in the form of a circle, in which they plant large round stakes, twice the height of a man, and set closely together. At the place where the entrance is to be, the circle is somewhat drawn in, after the fashion of a snail-shell, making the opening so narrow as not to admit more than two at a time. The bed of the stream is also turned into this entrance. At the head of the entrance, a small round building is usually erected; within the passage is placed another. Each of them is pierced with slits and holes for observation, and is handsomely finished off after the manner of the country. In these guard-houses are placed those sentinels who can scent the trail of enemies at a great distance. As soon as their sense of smelling tells them that some are near, they hasten out, and, having found them, raise an alarm. The inhabitants on hearing

the shouting immediately fly to the defence of the town, armed with bows, arrows, and clubs.

"In the middle of the town stands the king's palace, sunk somewhat below the level of the ground, on account of the heat of the sun. Around it are ranged the houses of the nobles, all slightly covered with palm branches; for they make use of them only during nine months of the year, passing, as we have said, the other three months in the woods. When they return, they take to their houses again; unless, indeed, they have been burnt down in the meantime by their enemies, in which case they build themselves new ones of similar materials. Such is the magnificence of Indian palaces."

Among the Indians to the westward of the Mississippi, particularly among the Mandans and kindred tribes, a somewhat different system of defence prevailed. The serpentine courses of the rivers, all of which have here high steep banks, leave many projecting points of land on elevated peninsulas, protected on nearly all sides by the streams, and capable, with little artificial aid, of being made effective for defensive purposes. Mr. Catlin describes the principal village of the Mandans, while that remarkable tribe existed, as protected upon three sides by the river, and upon the fourth "by a strong picket, with an interior ditch, three or four feet in depth." The picket was composed of timbers a foot or more in diameter and eighteen feet high, set firmly in the ground, at a sufficient distance from each other to admit guns to be fired between them. The warriors stationed themselves in the ditch during an attack, and were thus almost completely protected from their assailants. These practices seem, however, to be of comparatively late introduction.—(*N. A. Indians*, Vol. I., p. 81.)

Brackenridge (*Views of Louisiana*, p. 242) mentions the ruins of an Indian town upon the Missouri River, fifty miles above the mouth of the Shienne. The spot was marked by "great piles of Buffalo bones and quantities of earthen-ware. The village appeared to have been scattered around a kind of citadel or fortification, enclosing from four to five acres, in an oval form." The earth was thrown up about four feet, and a few of the palisades were remaining. The Shienne River is 1300 miles above the mouth of the Missouri. Lewis and Clark also mention a number of remains of Indian fortifications of like character, but it is to be observed that they distinguish between them and the larger and more imposing ancient works which fell under their notice in the same region. They describe an abandoned village of the Riccarees, called Lahoocat, which was situated in the centre of Goodhope Island. It contained seventeen lodges, surrounded by a circular wall, and is known to have been occupied in 1797.—(*Exp.*, p. 72.) They also mention the remains of a deserted village, erected by *Petit Arc* or Little Bow, an Omahaw chief, on the banks of a small creek of the same name, emptying into the Missouri. It was surrounded by a wall of earth about four feet high.—(*Exp.*, p. 41.) A circular work of earth, formerly enclosing a village of the Shiennes, was noticed by these explorers, a short distance above the mouth of the Shienne River.—(*Exp.*, p. 80.) The ancient villages of the Mandans, nine of which were observed in the same vicinity, within a space of twenty miles, were indicated by the walls which surrounded them, the fallen heaps of earth which covered the huts,

and by the scattered teeth and bones of men and animals.—(*Exp.*, p. 84.) Another defensive work, probably designed for temporary protection, was observed by these gentlemen in the vicinity of the mouth of the Yellowstone. "It was built upon the level bottom, in the form of a circle, fifty feet in diameter, and was composed of logs lapping over each other, about five feet high, and covered on the outside with bark set upright. The entrance was guarded by a work on each side of it, facing the river." These entrenchments, they were informed, are frequently made by the Minaterees and other Indians at war with the Shoshonees, when pursued by their enemies on horseback.—(*Exp.*, p. 622.) Lieut. Fremont found similar constructions in the vicinity of the Arkansas. A much more feasible method of protection, under such circumstances, is mentioned by Pike. He states that the Sioux, when in danger from their enemies in the plains, soon cover themselves by digging holes with their knives, and throwing up small breastworks.—(*Exp.*, p. 19.) They are represented as being able to bury themselves from sight, in an incredibly short space of time.

The numerous traces upon the Missouri of old villages occupying similar positions, and having evidently been defended in a like manner with those above described, place it beyond doubt that this method of fortification was not of recent origin among those Indians. Mr. Catlin mentions that there are several ruined villages of the Mandans, Minaterees and Riccarees, on the banks of the river, below the towns then occupied, which have been abandoned since intercourse became established with the whites.

Prince Maximilian notices a feature in the defences of the Mandan village of Mih-tutta-hang-kush, which does not seem to have been remarked by any other traveler. This village is represented to have consisted of about sixty huts, surrounded by palisades, forming a defence, at the angles of which were "conical mounds, covered with a facing of wicker-work, and having embrasures, completely commanding the river and plain." In another place, however, our author adds, that these bastions were erected for the Indians by the whites.—(*Travels in the Interior of North America, by Maximilian, Prince of Weid*, pp., 173, 243.)

DEFENCES OF THE ANCIENT MEXICANS AND PERUVIANS.

It will be seen, from what has been presented, that, while the Indian tribes on the Atlantic coast and along the Gulf of Mexico, with few exceptions, defended themselves with simple stockades, the Indians to the west of the Mississippi frequently added an embankment of earth, though in other respects observing a very great uniformity with those nations first named. This difference may be accounted for,

to a certain extent, by the nature of the soil, which, at the West, is generally readily excavated with the simplest tools.

Among the semi-civilized inhabitants of Mexico, Central America, and Peru, similar methods of defence were practised; but in the construction of their fortresses, they displayed a degree of superiority, corresponding to that which, in most other respects, they sustained over their savage contemporaries. Cortez found himself opposed, upon his first landing at Tobasco, by the town of that name, which, according to De Solis, was fortified after the usual method on the coast. The defences consisted of "a kind of wall made of the trunks of large trees, fixed in the ground after the manner of palisades, but so placed that there was room for the Indians to discharge their arrows between them. The work was round, without any traverses or other defences, and at the closing of the circle the extremity of one line covered the other, and formed a narrow, winding street, in which there were two or three little castles of wood, which filled up the passage, and in which were posted their sentinels. This," continues Solis, "was a sufficient fortress against the arms of the New World, when they were happily ignorant of the arts of war and of those methods to attack and defend, in which mankind has been instructed either by malice or necessity."—(*De Solis' Hist. Mexico*, p. 54.) This town, corresponding entirely with those described by the followers of De Soto, in Florida, seems to have been rudely fortified in comparison with others in the interior of the country, and nearer the seat of Aztec civilization.* Here the towns and cities were surrounded not only by palisades, but also by ditches and walls of earth and solid masonry. The skill with which the city of Mexico was protected is amply attested by the chroniclers of Cortez's expedition, and by that conqueror himself, who also inform us that walls were sometimes erected to guard the frontiers of provinces. The great wall of Tlascalla furnishes, in its extent, a parallel to some of the more imposing defensive structures of the other hemisphere. It was erected, according to Cortez, by the "ancient inhabitants" of that republic, as a protection against their enemies; and Clavigero asserts that other portions of the frontier were defended in a similar manner. De Solis describes it as "a great wall which ran across a valley from one mountain to another, entirely stopping up the way; a sumptuous and strong piece of workmanship, which showed the power and greatness of the builders. The outside was of hewn stone, united with mortar of extraordinary strength. It was twenty feet thick and a fathom and a half high; and on the top was a parapet after the manner of our fortifications. The entrance

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* The savage Indian tribes of South America possessed a like system of defence. Those of Brazil fortified their towns with palisades, and the Indians of Buenos Ayres, Paraguay, and Chili, constructed additional ramparts and ditches. Charlevoix describes those of the last named country as having forts, "surrounded by ditches and trenches, and protected by strong palisades, and pointed stakes of a very hard wood driven in the earth."—(*Southey's Hist. Brazil*, Vol. II., pp. 162, 189; *Mendoza in Purchas.*, Vol. IV., pp, 1352, 1356, 1361; *Charlevoix's Paraguay*, Vol I., p. 156; *Oralle's Chili, in Pinkerton*, Vol XIV., p. 113.) The natives of the Barbadoes Islands constructed defences of the same character. They selected eminences for their forts, and protected them with trenches and palisades. From these points they rolled down stones and logs upon their assailants.—*Davis' Hist. Barbadoes*, p. 325.

was narrow and winding, the wall in that part dividing and making two walls, which circularly crossed each other for the space of ten paces."* Clavigero states that it was six miles in length, eight feet in height, besides the parapet, and eighteen feet in thickness, composed of stone cemented with mortar. Works also existed in Mexico which approached more nearly to the character of the modern forts. They were, for the most part, strong, natural positions, such as isolated eminences, or the summits of steep and rugged mountains.

One of these, enclosing the ruins of many imposing temples and edifices, is situated to the north of the city of Mexico, in the department of Zacatecas, which is supposed to have been formerly occupied by the Chichimecs and Otomies. It is now known as the "Ruins of Quemada." The ruins are situated upon the summit of a high hill or *cerro*, and are inclosed upon the north, where the ground is sloping, by broad, double walls of massive stones cemented with mortar. Upon the south are rugged precipices, affording natural defences. The walls have bastions at intervals, and are entered by four broad roads, or causeways, which extend in different directions over the adjacent plain.

The hill of Xochicalco is three hundred feet in height, and a league in circumference, surrounded at the base by a deep and wide ditch. Whether designed as a temple or fortress, is not apparent. It may have subserved both purposes; for there is ample evidence, in the records of the conquerors, that the sacred grounds of the Aztecs were their places of last resort, in the defence of which their valor was inflamed by religious zeal. The summit of the hill of Xochicalco is attained by five spiral terraces, faced with cemented stones and supported by bulwarks, and is crowned by the ruins of edifices, which rank among the most imposing remains of the continent.

An ancient fortress, which no doubt well illustrates the character of the ancient Mexican defences, is figured and described by Du Paix. A plan of it is presented in the subjoined engraving, Fig. 30. "It occupies the summit of a steep, isolated rock, about a league west of Mitlan. This rock is accessible only from the eastern side. The wall is of solid stone, twenty-one feet thick and eighteen high, and is about a league in extent. It forms, in its course, several salient and retiring angles, with curtains interposed. On its assailable side, where is its principal entrance, it is defended by double walls, which mutually flank each other. The first, or most advanced, forms an *enceinte*, or elliptical rampart, upon which, at short intervals, there are heaps of small round stones for slinging, and in the centre of the crescent there is an oblique gate, to avoid the enfilade or right line of arrows, darts, and stones. The second wall, which is joined at its extremities to that of the fortress, is of greater elevation, and forms a sort of *tenaille*. It differs from the other in having its sides or flanks more open. It has likewise its rampart and heaps of stones. For greater security, batteries were disposed in the Aztec system of

* This feature is well illustrated in many of the defensive structures of the Mississippi valley, in which precisely similar expedients were adopted to secure the entrances. See Vol. I. of these Contributions, Plates IV., VI., VIII., etc.

defence, in front of the fortification, consisting of loose round stones, about three feet in diameter, placed high, and so balanced as to be easily precipitated below. On the plain surface of the rock are various ruins of square buildings and edifices, of considerable size, which were probably the ancient barracks. In the point diametrically opposite the entrance, is a sally-port or postern, for furnishing the fort with men and provisions, or to facilitate a forced retreat."

Fig. 30.

Near the village of Molcaxac are the remains of an ancient fortress, much resembling that here described. It occupies the summit of a mountain, and consists of four concentric walls of great strength and solidity.—(*De Solis*, Book II., p. 139.) Another fortress of similar character is mentioned by Clavigero as existing at Guatusco, twenty-five miles north of Cordova. It consists of high walls of stone, and is only entered by high and narrow flights of steps.

Although the above examples may serve to convey a very good idea of the nature of the defensive structures of the Mexicans, it is yet to be regretted that so brief and imperfect accounts of them have been transmitted to us by the early writers. While we are constantly assured of their existence, their great extent and vast strength, we are left in the dark in respect to their details.

More is known concerning the military works of Peru, and all accounts concur in representing them as clearly resembling those already described. According to Ulloa, a method of fortification existed, nearly allied to that practised by the ancient Celts. It consisted in digging three or four ranges of moats quite around the tops of high and steep mountains, protecting them on the inside by walls of earth or stone. These were called *pucuras ;* and, in some of them, the outer circumvallation is represented as having been upward of three miles in extent. In respect to their number, he asserts that one scarcely meets with a mountain without them.—(*Ulloa*, Vol. I., p. 504; Vol. II., p. 113.) Some were composed of rough stones, without arrangement; others of adobes. The more irregular of these

were attributed to the Indians before they were reduced by the Incas. La Vega describes the great fortress of Cuzco as constructed of three immense cyclopean walls, built rather of rocks than stones, surrounding a hill. Acosta measured some of the stones, and found them thirty feet in length, eighteen in breadth, and six in thickness. The outer wall is said to have been twelve hundred feet in compass. Through the walls were gateways, communicating with the interior, where, according to La Vega, were three strong towers, two of which were square and one round; the latter appropriated to the use of the Incas, the former to the garrison. Under the towers were subterranean passages of great extent.—(*McCulloch*, p. 272; *Bradford*, p. 169; *Ulloa*, Vol. II., p. 457.) It was supplied with water from a fountain in the centre. This is the fortress which so long resisted the attacks of the Spaniards. Similar works exist near the village of Baños, in Huamalies, occupying the summits of two mountains, placed opposite to each other on either side of the river. The sides of the mountains are divided into galleries, ranged one above the other, in some places formed by artificial walls, and in others cut in the solid rock.—(*Mercurio, Peruano*, Vol. V., p. 259; *Stevenson*, Vol. II., p. 100.) On the road from Potosi to Tacua, are the ruins of an ancient Peruvian city. Upon one side it is protected by a deep ravine, and on the other by a rampart, the stones composing which are dovetailed together in a very singular manner. Within the walls was a citadel, or place of last resort.—(*Andrews' Travels in S. A.*, Vol. II., p. 161.) Ulloa mentions the ruins of a fortified palace of the Incas, near Patasilca, one hundred and twenty miles from Lima. "The ruins are of very great extent: the walls are of tempered clay, and about six feet thick. The principal building stood upon an eminence, but the walls were continued to the foot of it, like regular circumvallations; the ascent wound round the hill, leaving many angles, which probably served as outworks to defend the place. It is called *Fortalesa*, and is supposed to have been a frontier point during the time of the Incas."—(*Ulloa*, Vol II., p. 27; *Stevenson*, Vol. II., p. 23.)

There are also evidences that, on the frontiers of certain portions of Peru, were constructed walls similar in design to that of Tlascalla. Such a one is said to cross the valley of Guarmey.—(*Ruschenberger*, p. 361.) Analogous works exist in Chili.—(*Frezier*, p. 262; *Molina*, Vol. II., pp. 10, 68.)

The fortifications of Central America are very much of the same character with those already described. Juarros gives an account of one of these situated upon the river Socoleo. "The approach, as usual to such places, was by a single entrance, and that so narrow as scarcely to permit a horseman to pass it. From the entrance there ran on the right hand a parapet raised on the berme of the fosse, extending along nearly the whole of that side; several vestiges of the counterscarp and curtain of the walls still remain, besides parts of other works, the use of which cannot now be easily discovered. In the court-yard there stood some large columns, upon which were placed quantities of pine wood, that being set on fire, gave light at night to the surrounding neighborhood. The citadel of this great fortification was in the form of a square graduated pyramid, rising twelve or fourteen yards from the base to the platform on the top, which was sufficient to admit of ten soldiers upon a side, etc. Every part of this fortress was constructed of hewn stones,

of great size; one of which being displaced, measured three yards in length by one in breadth.—(*Juarros' Hist. Guat.*, p. 462.)

The ruins of Uxmal, in Yucatan, described by Mr. Stephens, are represented to be enclosed by a wall of loose stones.—(*Stephens' Yucatan*, Vol. I., pp. 165, 230.) It was not, however, completely traced by that gentleman. Enclosing the ruins of Tuloom he found a well-constructed wall of regular outline, as represented in Fig. 31.

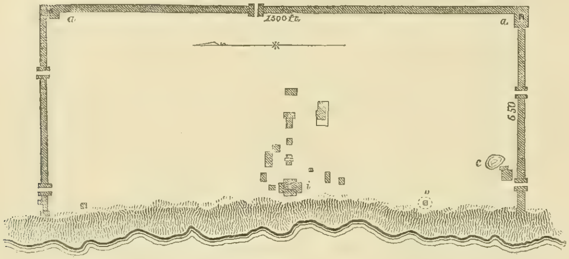

FIG. 31.

It forms three sides of a parallelogram, the fourth side, toward the sea, being bounded by a precipitous cliff. "It is of rude construction, and composed of rough, flat stones, laid upon each other without mortar or cement of any kind, and varies from eight to thirteen feet in thickness. The south side has two gateways, each about five feet wide. At the distance of six hundred and fifty feet, the wall turns at right angles and runs parallel to the sea. At the angle, elevated so as to give a commanding view, is a watch-tower, twelve feet square, which has two doorways. The interior is plain, and against the back wall is a small altar, at which the guard might offer up prayers for the preservation of the city. The west line, parallel with the sea, has a single gateway; at the angle is another watch-tower, like that before described, and the wall then runs straight to the sea. The whole circuit is 2,800 feet.—(*Stephens' Yucatan*, Vol. II., p. 396.)

The remarkable structures within this work, seem to be of a religious origin, suggesting the probability that it was designed as a sacred enclosure. It is not impossible that, as in the case of some of the works of the Aztecs, it was the citadel of the surrounding population, within which, in times of danger, they sought the protection and assistance of their gods. The fortified hill in the vicinity of Granville, Ohio, has a small sacred enclosure within its walls.—("*Ancient Monuments of Mississippi Valley*," Plate IX.) May it not furnish a rude type of the more imposing work above described, and denote a similar practice?

COMPARISON OF THE DEFENSIVE STRUCTURES OF THE AMERICAN ABORIGINES, WITH THOSE OF THE PACIFIC ISLANDERS, CELTS, ETC.

The resemblances which the defensive works of the mound builders, as well as of the later and existing Indian tribes, bear to those of many other rude nations, in various parts of the world, are no less striking than interesting. These resemblances have, however, had the effect of misleading superficial investigators, or those who have only paid incidental attention to these subjects. They have hastily inferred that, because certain monuments and aboriginal relics of the United States, such as entrenched hills, tumuli, and instruments and ornaments of stone and copper, sustain analogies, in some instances almost amounting to identities, with those occurring in the British Islands and on the Steppes of Russia, that relations must necessarily have existed between the builders, or that they had a common origin. These resemblances are, nevertheless, the inevitable results of similar conditions; and the ancient Celts and Scythians, the American Indians, and the natives of Australia, built their hill-forts, and fashioned their flint arrow-points and stone axes in like manner, because they thus accomplished common objects, in the simplest and most obvious mode. Human development must be, if not in precisely the same channels, in the same direction, and must pass through the same stages. We cannot be surprised, therefore, that the earlier, as in fact the later monuments of every people, exhibit resemblances more or less striking. What is thus true physically, or rather *monumentally*, is not less so in respect to intellectual and moral development. And it is not to be denied that the want of a sufficient allowance, for natural and inevitable coincidences, has led to many errors in tracing the origin and affinities of nations.

We not only find in the British islands, but also in the islands of the Pacific ocean, the almost exact counterparts of the defensive structures of our own country. "The places of defence of the Sandwich Islanders," says Ellis, "were rocky fortresses improved by art—narrow defiles or valleys, sheltered by projecting eminences—passes among the mountains, difficult of access, yet allowing their inmates a secure and extensive range, and an unobstructed passage to some stream or spring. The celebrated *Pare* (fortress), in Atehuru, was of this kind; the mouth of the valley in which it was situated was built up with a stone wall, and those who fled thither for shelter were usually able to repel their assailants.

"Several of these places are very extensive: that at *Maeva* in Huahine, near Mouna Tabui, is probably the best in the islands. It is a square of about half a mile on each side, and encloses many acres of ground well stocked with bread

fruit, containing several springs, and having within its precincts the principal temple of their tutelar deity. The walls are of solid stone-work, twelve feet in height. On the top of the walls, which were even and well paved, and in some places ten or twelve feet thick, the warriors kept watch and slept. Their houses were built within, and it was considered sufficiently large to contain the whole population. There were four principal openings in the wall, at regular distances from each other, that at the west being called the king's road. They were designed for ingress and egress, and during a siege, were built up with loose stones, when it was considered a *pari haabuea*, an impregnable fortress."—(*Ellis' Polynesian Researches*, Vol. I., pp. 313, 314.)

The New Zealanders were not deficient in defensive skill. Cook describes one of their strongholds or *Heppahs* at length. His account, from the light which it affords as to the probable manner in which the embankments of the western works were surmounted, is subjoined entire:

"Near this place is a high point or peninsula projecting into the river, and upon it are the remains of a fort, which they call Eppah or Heppah. The best engineers could not have chosen a situation better adapted to enable a small number to defend themselves against a greater. The steepness of the cliffs renders it wholly inaccessible from the water, which encloses it on three sides; and, to the land, it is fortified by a ditch, and a bank raised on the inside. From the top of the bank to the bottom of the ditch is twenty-two feet; the ditch on the outside is fourteen feet deep, and broad in proportion. The whole seemed to be executed with great judgment, and there had been a row of palisadoes, both on the top of the bank and along the brink of the ditch on the outside: those on the outside had been driven very deep in the ground, and were inclined towards the ditch so as to project over it; but of these, the thickest only were left, and upon them were evident marks of fire, so that the place had probably been taken and destroyed by an enemy. If occasion should make it necessary for a ship to winter or stay here, tents might be built in this place, which is sufficiently spacious, and might easily be made impregnable to the whole country."—(*Cook's Second Voyage.*)

The following additional particulars respecting the construction and defence of the *Heppah*, by a later writer, and a long resident of New Zealand, may serve to explain some of the features of the aboriginal structures of our own country, as also the probable manner in which they were defended.

"The fortifications of the natives are called *Pá* (*fort*), or *E' Pá* (*the fort*). The spots chosen for these defences equally evince sound judgment and habitual fear. The position accounted as best adapted for the purpose, is the summit of a high hill, overlooking the surrounding country, or a mountainous pass, having at its foot a river or running stream. Insular retreats, distant a few miles from the main, are also in especial repute. The first procedure is to *escarp* the hill, so as to render the ascent difficult and dangerous to a foe. Remains of such works are to be found on every remarkable elevation throughout the country. The further defences consist of two, sometimes of three stout stockades of irregularly sized posts and poles, varying from eight to thirty feet high from the ground, into which they are thrust from three to seven feet. The large posts are placed about a

dozen feet apart, on which are often carved ludicrous representations of men and animals; the spaces between the poles being filled with stakes, placed close together, and bound firmly with horizontal pieces by a creeper called *toro-toro*, which is tough and serviceable for a long period. These strongholds have often proved superior to any force the natives could bring against them. Few instances have occurred of a *Pá* being taken by a brisk siege; they have failed only when cowardice, treachery, or improvidence have aided the assailants. The stockades that enclose the fort are within a few feet of each other, the outer gate or entrance being much less than the inner opening, which, in time of war, is entered by stepping-stones or small wooden posts like a turnstile. The width is so contracted as scarcely to admit a large-sized man, and between the fences a fosse is often cut, about four feet in depth, sheltering the besieged while discharging their missiles at the enemy. A more confused scene can scarcely be conceived than a *Pá* during a siege. Some hundreds of low arched huts lie huddled together without regularity, streets, or paths; among these, some native palaces raise their roofs, and platforms (watás) built on trees for the preservation of food, and not for defensive purposes. Mounds are often erected during a night by an enemy, to overlook the interior of a fort, but they are of rare occurrence. The huts near the *tiápa* or stockades are covered with earth and clay, to render them secure to the inmates.

"Some forts have been selected with consummate skill, having the command of mountain gorges and narrow passes, which might keep in ckeck an army, if defended by a handful of brave men. Various contrivances are invented to render an approach to a fortification difficult of access. Sometimes a wooden post with notches for the feet affords the only means of entering the fort. The *Pá* formed by the celebrated E'Ongi, on a promontory jutting into Lake *Moperri*, was a work of much merit, and added greatly to the consequence of the self-taught engineer among his countrymen."—(*Pollock's New Zealand*, Vol. II., p. 26.)

It appears from these facts, that whatever estimate we may place upon the capabilities of the Pacific and South Sea Islanders, in other respects, they are, in the language of a close observer, "sufficiently advanced in civilization to construct fortifications, and adapt them to the nature of the country in which they are required."—(*Laing's Polynesian Nations*, p. 108.)

The defensive works of Great Britain present a great variety of forms, betraying different authors and different eras of construction. First of all, we have the works of the ancient Celts, of irregular outline, and occupying strong natural positions. These are succeeded by the fortified camps and other defences of the Roman era, which are followed by the less regular but more laborious works of the Belgic or Saxon period.

During the earliest or Celtic period, a large proportion of the barrows or tumuli scattered over the islands, were erected; then, also, were built those mysterious circles and long avenues which bear so striking a resemblance to the ancient structures of our own country.

In the choice of their military positions, the ancient Britons were governed by the same obvious rules which regulated the mound builders, and the American Indians generally—advantage in all cases being taken of the natural features of

the country. Their defences were usually erected on headlands, a single wall being carried along the brow of the promontory, while the level approaches were protected by a succession of embankments and ditches, with occasional outworks or advance posts. In some instances, steep, isolated hills were selected, which were defended by a series of concentric embankments, completely encircling the summit; a method of construction, as we have already seen, most frequently adopted by the Peruvians.

The subjoined examples of ancient British fortresses, are reduced from plans presented by Sir R. C. Hoare.

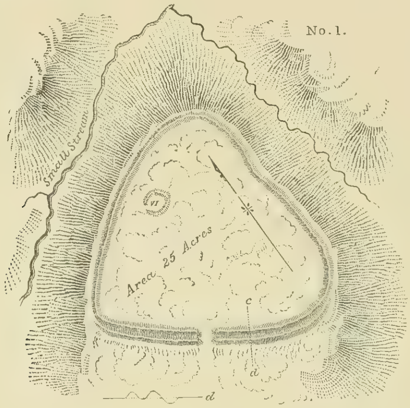

Fig. 32.

Fig. 32 is situated in the county of Wilts, in the parish of Colerne, near the road leading to Bath, and is known to British antiquaries under the different titles of "North Wood" and "Bury Wood Camp." "Its shape resembles that of a heart, its pointed part resting in an angle between two streams. Its area comprehends twenty-five acres, and it appears to have had only one entrance towards the S. W., and that placed exactly in the centre of the ramparts, which on this side are double, and rectilinear, the ground being level and must accessible on this side. On the N. W. side, near the outward vallum, but within the area of the camp, is a small earthen work (*a*), single ditched, with an entrance to the west."—(*Ancient Wiltshire*, Vol. II., p. 104.

Fig. 33 is situated in the same section of country with the work just described, in the vicinity of Castle Combe, from which it is named. "It is placed," says Hoare, "in a very strange and picturesque situation, on the point of a very steep hill, at whose base flows a rapid brook. It is very difficult of access. The foundation of walls, a raised mound, and other circumstances induce me to attribute to it a Saxon origin; and history reports its having been ravaged by the Danes. Its area is eight and a half acres; its form is rather oblong, but wider towards the north, where the ground is most easy of access, and where the adit into the camp has been placed. On entering the work at this point, and proceeding towards the

southern extremity, where the ground is most precipitate, we meet with three lines of ramparts, which intersect the area of the camp, through two of which there is an opening: the eastern point was fortified by a raised mound."—(*Ib.* Vol. II., p. 101.)

FIG. 33.

The singular *vitrified forts* of Scotland, are suggested in this connection. They appear to have been composed of loose stones, which, by some process of vitrification, were made to present the outward features of solid rocks, and have long perplexed antiquarians. Some have attributed the vitrification to lightning, others to accidental conflagration, while a few, more daring in their speculations, have considered them the craters of extinguished volcanoes! It has also been supposed that vast defences of wood once surrounded and surmounted the ramparts, by the casual burning of which they were vitrified. There is, however, every reason to believe, that this feature was the result of design, although it is not easy to explain how it was produced. Dr. Anderson, in a communication to the Society of Antiquarians, in 1777, gives an account of a remarkable work of this description, called

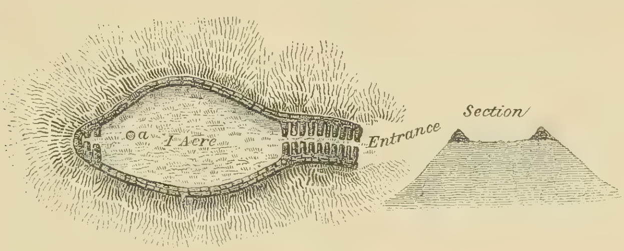

FIG. 34.

Knockferral, in Ross-Shire. It is placed on a high ridge of an oblong shaped hill, very steep on three sides, the walls being raised on the edge of a precipice all

round, except at the end admitting entrance into the area, the enclosed space of nearly an acre being level: features readily recognizable as also belonging to our American "Hill Forts." The approaches to this work, as those of all others of the same description, are strengthened by additional ramparts. "Those at the entry," says our authority, "had extended, as I guessed, about one hundred yards, and seemed to have consisted of cross-walls, one behind the other, eight or ten in number; the ruins of which are still plainly perceptible. Through each of these walls there must have been a gate, so that the besiegers would have been under the necessity of forcing each of these gates successively, before they could carry the fort; on the opposite end of the hill, as the ground is considerably steeper, the outworks seem not to have extended above twenty yards. Not far from the farther end, was a well (*a*), now filled up. The wall all around from the inside appears to be only a mound of rubbish, consisting of loose stones: the vitrified wall is only to be seen from the outside. Here the wall is covered with a crust of about two feet in thickness, consisting of stones immersed among vitrified matter; some of the stones being half fused themselves,—all of them having evidently suffered a considerable heat. The crust is of an equal thickness—of about two feet—from the top to the bottom, so as to lie upon, and be supported by, a backing of loose stones, forming in section an acute angle. Within the crust of the vitrified matter is another stratum of some thickness, parallel to the former, and consists of loose stones, which have been scorched by the fire, but present no marks of fusion."

It will be perceived that in position, mode of construction, etc., these defences are indistinguishable from those of America. They might be regarded, so far as their apparent features are concerned, as the work of the same people; yet they were constructed by different races, separated from each other by ocean wastes, and having little in common, except the possession of those savage passions which have reddened every page of the world's history with blood. They serve only further to illustrate how naturally, and almost of necessity, men similarly circumstanced hit upon common methods of meeting their wants, and do not necessarily establish a common origin, nor a constant or casual intercourse.

The Roman camps, vestiges of which are abundant throughout England and on the continent, also bear a close analogy to a large class of the more regular Western earth works, though probably differing widely from them in the purposes for which they were erected. "The Romans, from the earliest period, paid particular attention to the security of their armies, by choosing the best situations for their camps that the circumstances would permit. They did not, however, trust to natural strength alone—making it an invariable rule, wherever they came, to enclose themselves within an entrenchment, consisting of a rampart and ditch strengthened with palisades. The fortifications were of a stronger or weaker character, according to the nearness of an enemy, or the appearance of danger with which they were threatened at the time. The form of the Roman camp was square, contrary to that adopted by the Greeks, who made theirs round, triangular, or of any other shape, as best suited the nature of the ground."—(*Roy's Military Antiquities of England*, p. 41.) The angles of the Roman camp were rounded, on a radius of about sixty feet, and there were gateways midway upon each side;

sometimes, if the camps were of large size, there were several passages upon each side. These entrances were usually protected by exterior mounds, or by overlapping walls, and occasionally outworks were erected. The temporary camps, *castra æstiva*, or those not designed for constant occupation, had comparatively slight entrenchments, the ditch being about six feet deep, and the parapet behind it only about four feet high. The *castra stativa* were generally much smaller than the temporary camps, and were strongly protected. They were designed to contain garrisons, either to guard a frontier or keep in awe newly conquered provinces. Two ranges of them were erected shortly after the time of Agricola, upon the frontiers of Caledonia, placed at short intervals apart between the Clyde and Forth, and the Tyne and Solway, nearly upon the line afterwards occupied by the walls of Hadrian, Antoninus Pius, and Severus. The smaller sort of *castra stativa* were termed *castella*, answering in a great degree to the field-forts and redoubts made use of by modern armies.

FIG. 35.

The above cut, Fig. 35, is a plan of the camp of a single Roman legion, according to Polybius, and is introduced more to illustrate the different methods of protecting the gateways, than to serve any other purpose. In some of the Western military works, as may be seen by reference to the first volume of these Contributions, gateways occur similar to that at A. In the more regular structures of the West, however, the mound covering the gateway is invariably placed *interior* to the walls, which circumstance, joined to others less equivocal, goes to sustain the conclusion that such works were not constructed for defence. The Roman camps had frequently two, sometimes four or more, lines of embankment, with flanking defences, horn-works, etc. The stone and earth circles of England are all ascribed to the Celts; the rectangular works to the Romans. Throughout the islands, no works occur in which the two figures are combined, as in the Mississippi valley.

CONSTRUCTION OF MOUNDS BY THE EXISTING INDIAN TRIBES.

We have, in the quotation from Bartram, on page 68, evidence (not the most conclusive, it is true), that some of the mounds of the South were general cemeteries, and are not of a very high antiquity. Recent investigations have shown that burials in these were frequent; but this was seldom the primary purpose to which they were dedicated. Most of the mounds of the South were of sacred origin—the "high places" and temples of the aborigines. Among the Natchez, the bones of the dead were placed in the temples of the tribe, and occasionally, if not always, finally buried there. These temples are represented to have been erected upon mounds or artificial elevations of earth; but it is not stated distinctly whether they were the work of this people, or simply appropriated by them. Within these temples, upon the death of the Suns or religious heads of the nation, were buried the victims which were put to death on the occasion.—(*Charlevoix*, Vol. II., p. 264; *Du Pratz*, p. 356.) These customs may account for the presence of numbers of human skeletons in some of these structures. The custom of burying in sacred places was of very general acceptance throughout the world: and the peculiar veneration which attached to tombs, often led to their consecration as temples.

In a letter dated Mt. Sylvan, Mississippi, August, 1847, Mr. R. Morris presents the following facts respecting the mounds of that region. "A mound which I opened last summer, twelve miles southeast from this place, had in it not less than fifty full skeletons, all pretty near the surface. They were packed without order, with layers of pounded clay between them. Those nearest the top were black and quite fresh, but lower down they were greatly decayed. No relics accompanied them, although in the graves where the later races buried their dead, are found many ornaments, utensils, and weapons.

"A few miles from Panola, there is a mound quite full of human bones. Hundreds may be thrown out with a sharpened cane. Another mound, about twelve miles north of the place just named, was opened a year or two since. In the centre was found a structure like a cistern, nearly round, four feet across, and filled with soil. This being removed, an earthen vessel of singular form and material was taken out."

The burial-mounds of Florida, from what we can gather concerning them, have peculiarities in the arrangement of the skeletons, not elsewhere observed. These mounds are seldom of large size, and do not generally appear to be connected with other works. They range from four to eighteen feet in height, and are usually comprised of earth and sand, but are sometimes principally made up of decayed shells. The skeletons, it is said, are found arranged in radiating circles, from top

to bottom, with the feet outward and the heads a little elevated, and are generally accompanied by rude vessels of pottery. In one of the mounds, on the St. John's River, a skeleton of large size was found, in a horizontal position, surrounded by others in a sitting posture. It has been conjectured that these belong to a later era than the grand system of earth-works of the Mississippi valley.

Mounds designed as *general cemeteries*, if indeed there be any in the Western States, are certainly few in number and of modern date. One, containing many skeletons disposed in layers, formerly existed in Belmont county, Ohio. Whether it was secondarily appropriated by the Indians or built by them, it is not presumed to say; the remains found in it were indubitably of the recent tribes and of late deposit.

The tumulus examined by Mr. Jefferson on the low grounds of the Ravenna River, and described in his "Notes on Virginia," is attributed by him to the recent tribes of Indians, by whom it was probably built. The stream on which it occurs is one of the lower branches of James River, which empties into the Atlantic. We have no satisfactory evidence that the race of the mounds passed over the Alleghanies; the existence, therefore, of a few tumuli to the east of these mountains, unless in connection with other and extensive works, such as seem to have marked every step of the progress of that race, is of little importance, and not at all conclusive upon this point; especially as it will hardly be denied that the existing races of Indians did and still do occasionally construct mounds of small size. This mound was estimated by Mr. Jefferson to contain the skeletons of a thousand individuals, a portion of which, particularly toward the surface, were placed without order, while the remainder seemed to have been deposited with a certain degree of regularity. This is certainly a very large estimate of the contents of a barrow but forty feet base by seven feet in height. It will not be out of place to remark here, that by the unpractised observer, the bones of a hundred skeletons placed together would probably be mistaken for those of several hundred or a thousand.

We have, it is true, but very few accounts of the construction of mounds by the existing tribes of Indians. Lewis and Clarke noticed, in their travels west of the Mississippi River, a spot "where one of the great chiefs of the Mahas or Omahas had been interred. He was buried on a hill, and a mound twelve feet in diameter and six feet in height erected over him."* Beck mentions a large mound on the Osage River, which had been erected within the last thirty or forty years, by the Osages, in honor of one of their dead chiefs.† Mention is made in the

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* Exp., vol. I., p. 43. "Blackbird (Wash-ing-gah-sahba), chief of the Omahaws, or Mahas, died in 1800, and was interred in a sitting posture on the back of his favorite horse, upon the summit of a high bluff of the Missouri, 'that he might see the white people ascend the river to trade with his nation.' A mound was raised over him, on which food was regularly placed for many years after; but this has been discontinued, and the flag-staff which crowned it has been removed."—*James's Exp.*, Vol. I., p. 204.

† Gaz. of Mo., p. 308; James Exp., Vol. II., p. 34.—This is probably the same mound referred to by Mr. Sibley, who derived his information from a chief of the Osages. "He stated that the mound was built, when he was a boy, over the body of a chief, called Jean Defoe by the French, who unexpectedly died while his warriors were absent on a hunting expedition. Upon their return, they heaped a mound over his remains, enlarging it at intervals for a long period, until it reached its present height."—*Featherstonhaugh's Trav.*, p. 70.

documents accompanying the President's message for 1806, of a "mound of considerable size," erected by the Natchez Indians, near Nachitoches, when they were expelled from Louisiana, in 1728. They are also said to have fortified themselves near this place. Mr. Catlin observed a conical mound, ten feet in height, at the celebrated pipe-stone quarries of the *Coteau des Prairies*, which had been erected over the body of a young chief of the Sioux tribe, who had been accidentally killed on the spot.—(*N. A. Indians*, Vol. II., p. 170.) James also presents, upon what he deems good authority, an account of the discovery, by a hunting party, in 1816, on the banks of the La Mine River, in Missouri, of a newly made mound; which, when opened, disclosed the body of a white officer, clothed in regimentals, placed in a sitting posture on a mat, and surrounded by a rude enclosure of logs, twelve feet long, three wide, and four high. He had evidently met a violent death, and had been scalped.—(*Narrative*, Vol. I., p. 84.) To what nation he belonged, and by whom the mound was erected, is unknown. The Mandans sometimes constructed little mounds of earth, not however for burial. They were connected, in some mysterious way, with their ceremonies for the dead. "Their dead," says Catlin, "are placed, closely enveloped in skins, upon scaffoldings, above the reach of wild animals. When the scaffolds decay and fall to the ground, the nearest relatives bury all the bones excepting the skull. The skulls are arranged in circles of a hundred or more, on the prairies, with their faces all looking to the centre. In the centre of each ring is erected a little mound, three feet high, on which are placed two buffalo skulls, a male and female; and in the centre is reared a medicine pole, supporting many curious articles of mystery and superstition, which they suppose to have the power of guarding and protecting this sacred arrangement. Here the relatives of the dead resort to hold converse with them, bringing a dish of food, which is set before the skull at night and taken away in the morning. Under each skull is constantly kept a bunch of fresh wild sage."—(*N. A. Indians*, Vol. I., p. 90.)

The Indians, it is well known, often heaped a pile of stones over the graves of such of their tribe as met their death by accident, or in the manner of whose death there was something sufficiently peculiar to excite their superstition. Such was the case, in one instance, in Scoharie county, on the Cherry Valley trail. But the construction of mounds, whether for purposes of burial or as monuments, except perhaps among some of the Southern tribes, was far from common, and cannot be regarded as a custom of general acceptance. The few which they built were clearly, in most instances, the result of caprice or of circumstances; and we are not justified in ascribing to them more than a very trifling proportion of the numerous tumuli which dot the plains and valleys of the West, and which, in their numbers and uniformity of structure and contents, give conclusive evidence that they were constructed for specific purposes, in accordance with a well recognised design, and an established and prevailing custom.

The practice of depositing the property of the dead in the tomb with them (almost universal among the American Indians) is of the highest antiquity, and was widely diffused amongst all primitive nations. "In all early ages," remarks an erudite writer, "when the disengaged activity of man ever carries a keen and

military edge with it, and his great employment is necessarily war and the chase, the weapons of both would naturally be deposited with the dead." We have a striking passage of Scripture, which shows the custom to have been as general as the spirit of ambition or the profession of arms: "They shall not lie down with the mighty which are gone down to hell [the grave] with their weapons of war; and they have laid their swords under their heads." Josephus tells us, that in David's sepulchre was deposited such a quantity of treasure, that Hyrcanus, the Maccabean, took three thousand talents out of it, about 1300 years after David's death, to get rid of Antiochus, then besieging Jerusalem.

Uniformity in the rites and ceremonies attending burial must not, however, be regarded as necessarily implying connections or relations between the nations exhibiting them; for most, if not all of those which may be esteemed of importance, had their origin in those primitive conceptions and notions which are inherent in man, and are in nowise derivative. In the universal recognition of a future existence, may be traced the origin of the immolations and sacrifices made at the tombs or on the pyres of the dead: the wife and the faithful servant sought to accompany their lord in his future life; and a numerous retinue was slain at the tomb of the Scythian King and the Peruvian Inca, that they might appear in a future state with a dignity and pomp proportionate to their earthly greatness. The Mexican slew the *techichi* at the grave of the dead, that his soul might have a companion in its journey along the dreary, terror-infested pathway, which, according to his superstitions, intervened between earth and the "blessed mansions of the sun." So, too, the faithful dog of the Indian hunter was placed beside him in the grave, that in the blissful "hunting-grounds of the West" he might "bear him company." The warlike Scandinavian had his horse sacrificed on his funeral pyre, and his weapons buried with him, so that, full armed and mounted, he might, with becoming state, approach the halls of Odin.—(*Mallet*, Chap. XII.) In the almost universal belief that the soul of the dead, for a longer or shorter period, lingered around the ashes from which it was separated, we may discover the reason why food and offerings were deposited at the grave; why it was carefully preserved; and why, at stated intervals, the surviving relatives of the deceased decked it with flowers and performed games around it. In some of these ceremonies it was believed the departed spirit silently participated, and with all it was supposed to be pleased and gratified.

SEPULCHRAL MOUNDS IN MEXICO, CENTRAL AMERICA, PERU, AND CHILI.

Mounds are found in Oregon; but little is known concerning them, except that they occur in the open prairies, are of small size (seldom more than six or seven feet in height), and are many thousands in number. Some of them were opened by Com. Wilkes, but found to contain nothing beyond a pavement of round stones. Their origin is involved in obscurity. Although professing to know nothing concerning them, the Indians nevertheless regard them with some degree of veneration. Their priests, or "medicine men," gather the wild herbs which grow upon them, for use in their incantations and superstitious rites. It seems unlikely that they were built by a people so rude as those found in present occupation of the country.—(*Exploring Expedition*, Vol. IV., p. 313.)

It is not known that any mounds occur in Upper or indeed in Lower California. A few are found in New Mexico, and in the valley of the Gila; but we are ignorant of their character and contents. The aboriginal Mexicans often buried in the pyramidal structures constituting their temples; and it is presumed, although we have no direct evidence of the fact, that they sometimes erected tumuli over their dead. The plain surrounding the great pyramids of Teotihuacan is covered with mounds, chiefly of stone, and disposed with a great deal of regularity; it is called *Micoatl*, or *Path of the Dead*.* These pyramids are, however, ascribed to the Toltecs, who preceded the Aztecs in the possession of the valley of Anahuac; and it is reasonable to believe that the numerous tumuli which surround them, whatever their purposes, were built by the same hands.

If the practice of erecting mounds over the dead prevailed at all among the Mexicans, it must have been to a very limited extent. This is inferred from the silence of all the ancient authorities, who, although giving us very minute accounts of their burial customs, say nothing concerning such structures. It was usual to burn the dead, and the rite was performed with many ceremonies. In cases where simple inhumation was practised, the body was placed in a sitting posture, in chambers of stone or brick, accompanied by their ornaments and the implements of their profession. Bernal Diaz mentions the explorations of Figuero, an officer among the conquerors who, in the territory of the Zapoticas, employed himself

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* Mr. Thompson, in his "Recollections of Mexico" (pp. 138, 142), expresses the opinion that what have been very generally supposed to be sepulchral mounds around these pyramids, are not such in fact, but simply the ruins of the houses composing an ancient town. His opinion, for reasons which the inquirer will find explained at large in his book, is entitled to consideration.

"in discovering the burial places of the Caziques, and in opening their graves for the sake of the golden ornaments which the inhabitants of *olden times* were accustomed to bury with their chiefs. This employment he prosecuted with so much vigor and success, that he collected in this manner over 100,000 dollars worth of gold.—(*Lockhart's Diaz*, Vol. II., p. 322.) It will be observed that Diaz speaks of these tombs as belonging to the people who inhabited the country in the olden time,—probably the Toltecs, amongst which branch of the American family the practice of mound-building seems to have been of universal prevalence.

Sepulchral mounds are abundant in many parts of Central America. In the vicinity of the ruins of Ichmul, in Yucatan, they are particularly numerous, covering the plain for miles in every direction. Some of these are forty feet in height. Several have been opened and found to contain chambers, enclosing skeletons, placed in a sitting position with small vessels of pottery at their feet.—(*Norman's Yucatan*, p. 146.) In Honduras, says Herrara, were many tombs of the inhabitants; "some of which were large plain rooms, and others only like great heaps of earth. In the territory of Zenu," continues this author, "abundance of graves were found in a field near a temple, so ancient that large trees were growing over them; and within them was an immense quantity of gold, besides what the Indians took, and what still is lost under ground. These graves were very magnificent, adorned with broad stones and vaults, in which the dead body was laid, and all their wealth, jewels, and arms, women and servants alive, with good stores of provisions and pitchers of their liquors, which denoted the knowledge they had of the immortality of the soul. The dead were buried sitting, clothed and well armed."—(*Herrara*, Vol. IV., p. 221.)

Mr. Stephens excavated a sepulchral mound in the vicinity of San Francisco, in Yucatan. It was a square stone structure, with sides four feet high; and the top was rounded over with stones and earth. The interior was loose earth and stones, with some layers of large flat stones, the whole very rough. After digging six hours, he came to a flat stone of large size, beneath which was a skeleton. The knees were bent against the stomach, the arms doubled from the elbow, and the hands supporting the neck or head. With this skeleton was found a large vase, the mouth of which was covered with a flat stone. It was empty, except some little, hard, black flakes at the bottom. Mr. Stephens conjectures that it may have contained some liquid, or the heart of the skeleton.—(*Trav. in Yucatan*, Vol. I., p. 277.)

In South America, and particularly in Peru, the custom of erecting mounds over the dead was of general prevalence. The sepulchral tumuli of Peru were called *huacas* or *guacas*. They exhibit many features in common with the burial mounds of the Mississippi valley, and establish that funeral customs, in many respects similar to those practised by the race of the mounds, prevailed among the ancient inhabitants of that country. Their form is generally that of a simple cone; sometimes they are slightly elliptical, and occasionally rectangular. Their usual height is said to be not far from forty to fifty feet, though some are mentioned which are upwards of one hundred feet in altitude. They are scattered in great profusion over the country; but, according to Ulloa, are "most abundant within the jurisdiction

of the town of Cayambe, where the plains are covered with them, for the reason that formerly here was one of the principal temples of the ancient inhabitants, which it was supposed communicated a sacred character to the surrounding country, which was therefore chosen for the burial-place of the kings and caziques of Quito; and in imitation of them, all the chiefs of the villages were interred there. The remarkable difference," continues this author, "in the magnitude of these monuments, seems to indicate that the guacas were always suitable to the character, dignity, or riches of the person interred, as indeed the vassals under some of the most potent caziques concurred in raising a mound over his body."—(*Ulloa*, Vol. I., p. 480.) It may be regarded as settled, that, as a general thing, none but the bodies of deceased chieftains and other persons of consequence were deposited in the *huacas*, and that those of the common people were buried in simple graves. Within the huacas, upon the original surface of the ground, are found chambers constructed of stone, brick, or timber; sometimes there are several of them, with connecting galleries, in which the dead were placed. The bodies are usually found occupying a sitting posture. With them were placed a great variety of articles, ornaments, and implements. Vast quantities of pottery, of every variety of form and ornament; articles of gold and silver, comprising ear-rings, pendants, bracelets, and little images of men and animals; axes of hardened copper and of stone, differing but slightly in shape from those in use at the present day; spear-heads and mirrors of obsidian (*gallinazo* stone); cloth of cotton, of the wool of the lama, and of other materials; implements of palm-wood; marine shells, and a thousand articles of similar character. Vast numbers of these tombs have been opened for the sake of the treasures they contain.*

In Chili, sepulchral mounds of earth and stone are of frequent occurrence. In them are found, besides the bones of the dead, earthenware, axes, and vessels of stone, admirably worked, and occasionally edged tools of hardened copper. Molina describes, with considerable minuteness, the funeral ceremonies of the Chilian Indians; which, from the light they may throw upon the customs of the mound-builders, are worthy of notice. "As soon as one of their nation dies, his friends and relations seat themselves on the ground round the body, and weep for a long time; they afterwards expose it, donned in its best clothes, upon a high bier, where it remains during the night, which they pass near it, weeping, or in eating or drinking with those who come to console them. This is called the black entertainment: black being with them, as with us, the sign of mourning. The following day, or within two or three days, they carry the corpse to the burial-

* The amount of treasure found in some of the huacas is very great. Stevenson states that in the year 1576, a huaca was opened in which was found gold amounting to 46,810 golden ounces; according to Humboldt, 5,000,000 francs. We are not surprised at the great value of some of these deposites, in view of the almost incredible quantities of gold and silver possessed by the ancient Peruvians. According to Proctor (*Peru in* 1823–24), the excavation of the ancient tombs for their contents is still carried on, though it seems that considerable quantities of the precious metals are seldom found. Mr. Proctor mentions that in some instances the spindles of the ancient inhabitants, with the cotton thread still perfect on them, have been found in the huacas.

place of the family, which is usually situated on a hill or in a wood. The corpse is preceded by two men at full speed on horseback, and is followed by the relations, with loud cries and lamentations, while a woman strews ashes on the track, to prevent the soul from returning. On arriving at the place of burial, the corpse is laid on the surface of the ground, surrounded, if a man, with his arms; if a woman, with female implements, and with a great quantity of provisions, and with vessels filled with *chica* and with wine, which, according to their opinion, are necessary to subsist them during their passage to another world. They sometimes even kill a horse and inter it in the same ground. After these ceremonies, they take leave, with many tears, of the deceased, wishing him a prosperous journey, and cover the body with earth and stones in a pyramidal form, upon which they pour a great quantity of *chica*."—(*Molina's Chili*, Vol. II., p. 82.)

The Esquimaux cover their dead with rude heaps of stone, above which they pile the sledges and canoes of the deceased. The bodies are usually closely wrapped in skins, and placed in a sitting posture.—(*Capt. Lyon's Narrative*, p. 68.) Kotzebue mentions a structure of stones which he designates as a "round tower, four fathoms in height," at Kotzebue Sound. It was probably a sepulchral monument of the savages.—(*Voyage*, Vol. I., p. 210.)

SEPULCHRAL MOUNDS AND MONUMENTS OF THE ANCIENT WORLD.

"The most enduring monuments of the primeval ages of society," observes a learned archæologist, "were those erected in memory of the dead; and it seems that the further we go back into the history of mankind, the deeper we find man's veneration for his departed brethren. The simplest, and also the most durable, method of preserving the memory of the departed, was by raising a barrow, or mound of stones, over his remains; and accordingly, we find instances of this mode of interment in almost all countries of the globe." The extent to which it prevailed in America, we have already indicated; and the coincidences in form and structure between the sepulchral monuments of this continent and those of the Old World, have been the subject of incidental remark. These coincidences are, however, sufficiently remarkable to merit further attention; and it is believed a brief review of the character of the primitive sepulchral monuments of the other continent will serve greatly to illustrate and explain those of our own country, at the same time that it establishes the general prevalence of the custom of mound-burial in past ages.

The earliest of human records distinctly refer to the practice of erecting mounds of earth or stone over the dead; but we find in the pyramids of Egypt—

which may be regarded as perfected tumuli—the evidence of its prevalence at a period long anteceding the dawn of written history. In the deep night of antiquity, step by step, had the rude heap of stones which filial regard first gathered over the dead, developed itself, until in its massive proportions and solid strength it emulated the mountains, and bade defiance to time. Homer speaks frequently of the sepulchral tumuli of the heroic age of early Greece, and gives many curious details relating to the ceremonies of the interment. The description of the burial of Patroclus is familiar to most readers; it, however, conveys so accurate and lively an idea of the practices common to ancient burials, that we cannot do better, in illustration of our subject, than to quote it here. It should be premised that the Homeric heroes were burnt before interment.

> "They still abiding heaped the pile.
> A hundred feet of breadth from side to side
> They gave to it, and on the summit placed,
> With sorrowing hearts, the body of the dead.
> Many a fat sheep, with many an ox full-horned,
> They flayed before the pile, busy their task
> Administering; and Peleus' son, the fat
> Taking from every victim, overspread
> Complete the body with it of his friend
> Patroclus, and the flayed beasts heaped around.
> Then, placing flagons on the pile, replete
> With oil and honey, he inclined their mouths
> Towards the bier, and slew and added next,
> Deep groaning and in haste, four martial steeds.
> Nine dogs the hero at his table fed;
> Of which beheading two, their carcasses
> He added also. Last, twelve gallant sons
> Of noble Trojans slaying (for his heart
> Teemed with great vengeance), he applied the force
> Of hungry flames that should devour the whole."
>
> *Iliad*, Book XXIII., COWPER'S *Version*.

The sacrifices done, and the body consumed, the bones are next collected and the tumulus heaped above.

> "The Greeks obey! Where yet the embers glow,
> Wide o'er the pile the sable wine they throw,
> And deep subsides the ashy heap below.
> Next the white bones his sad companions place,
> With tears collected, in the golden vase.
> The sacred relics to the tent they bore;
> The urn a veil of linen covered o'er.
> That done, they bid the sepulchre aspire,
> And cast the deep foundations round the pyre;
> High in the midst they heap the swelling bed
> Of rising earth, memorial of the dead."—*Iliad*, Book XXIII.

The Trojans are made to bury the body of Hector in the same manner: during nine days they collect the wood and raise the pile; and when fire has completed its part of the work, they also quench the fires with dark wine, and collect the bones of the hero in a golden urn, which they cover with a rich cloth, and place in a "hollow trench;" above this they pile large stones, and over all heap the tumulus.

The body of the dead was not always burned among the Greeks; on the contrary, burial both by inhumation and incremation was practised from the earliest times, though one practice may have been more common than another at a particular period. In Magna Græcia, unburnt skeletons have been found, and in tombs close by vases containing the ashes of the dead.—(*Tischiben and Böttiger.*) Both skeletons and ashes have been found in Greece itself.—(*Stackelberg, die Gräber der Hellenen.*) There are no certain accounts as to whether the body was burned at the place of sepulture, or at a spot designated for that purpose. At any rate, the remains were collected and deposited in a *cinerary* made of clay or bronze. The coffins of the unburned were sometimes of wood, but generally the work of the potter, though in some cases of masonry or stone. The tombs were usually in a spot designated for the purpose. Sometimes they were placed in the person's own house. After it was forbidden to bury in the city, it became common to select a certain quarter for burials. The favorite place of sepulture was in the fields or by some frequented highway. The tombs were the inviolate property of the family, so that no other person might bury therein. A variety of articles were placed with the dead—vases, mirrors, ornaments, etc. In cases of burning, they were placed on the pyre. Feasts and offerings to the dead were customary. At stated times the tombs were decked, and sometimes bloody sacrifices were made. In the order of funeral ceremonies, it should be mentioned that the first thing done was to insert a small coin (an *obolus*) in the mouth of the dead, as a ναῦλον for the ferryman of Hades. A similar custom existed among the ancient Mexicans, who inserted a gem of some kind in the lips of the deceased, which was to serve as a heart in the next world.

The funeral customs of the Romans were nearly identical with those practised by the Greeks. Their tombs were often simple tumuli, and so denominated. Burial by inhumation and by fire were common practices. In the tombs were placed coins, urns, flasks for holding tears or perfumes, sepulchral lamps, etc. Games were celebrated in honor of the dead, and sacrifices and libations made on their tombs.

Among both Greeks and Romans, the expenditures at funerals became so great, and the ambition to erect large and costly monuments so general, that it was found necessary to prescribe their dimensions, and check extravagance by law.

A pillar or upright stone, in ancient times a sacred emblem, was usually placed upon the tumulus of the dead. Paris wounded Diomedes from behind the pillar on the barrow of Ilus. These pillars were called *stelæ*. Alexander, when he crossed the Hellespont, performed solemn games at the barrows of the Grecian heroes who fell before the walls of Troy, and anointed with perfumes the *stelæ* on their tops. They were erected on the taphos of the Athenians who fell at

Marathon, and on that of the Lacedæmonians who died at Thermopylæ, and bore the names of the slain. The stelæ were continued when the barrows were no longer erected; and the idea of their sanctity is still retained in the monumental stones which plead for safety, by professing to be *sacred* to the memory of the person above whose grave they are erected.

Sometimes the arms or implements of the dead were suspended around the *stelæ* or crowned the barrow of the dead. A spear was fixed on the tomb of the Trojan Hector; and Misenus, the trumpeter of Hector, and pilot of the Trojan fleet of Æneas, had reared upon his tomb the symbols of his deeds.

> "On it Æneas piously heaped
> A mighty mound sepulchral. The oar, the trumpet,
> Arms of the man, the airy summit crowned,
> From him Misenus named. It still retains
> That name, and holds it through the lapse of time."*
>
> *Æneid*, IV., 232.

Even in the later periods of Grecian history, mounds are occasionally raised over the illustrious dead. Plutarch says that Alexander, on the death of Demaratus, "made a most magnificent funeral for him, his whole army raising him a monument of earth eighty cubits high and of vast circumference." Semiramis endeavored to eternize the memory of Ninus her husband, by raising a high mound for his tomb. The Scythians, whose tumuli are scattered in great abundance over the plains of Russia, southern Siberia, and Tartary, labored, says Herodotus, "to raise as high a monument of earth for their dead as possible." This author has left us a remarkable description of their mode of interment, which is amply confirmed by the exploration of their tombs. "The body of the king, having been transported through the various provinces of the kingdom, was brought at last to the Gerri, who live in the remotest parts of Scythia, where the sepulchres are. Here the corpse was placed upon a couch, encompassed on all sides by spears fixed in the ground: upon the whole were placed pieces of wood, covered with branches of willow. They strangled one of the deceased's concubines, his groom, cook, and most confidential servant, whose bodies they placed around the dead; they slew horses also, and deposited with him the first fruits of all things, and the choicest of his effects, and finally some golden goblets, for they possessed neither silver nor brass. This done, they heaped the earth above with great care, and

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* The practice here indicated was one of general prevalence, not only in ancient but in more modern times, and alike amongst savage and polished nations. The Indians around the Upper Mississippi, to this day, place a pole above the graves of their dead, from which his arms and ornaments are suspended; so, too, do the Indians of Oregon; who, however, distrusting the veneration of their fellows, break holes in the kettles, and bend the barrels of the guns which they place on the tombs. The arms and crest of the titled dead are still graven on their monuments, and the unstrung lyre and broken sword indicate the graves of the poet and the warrior. The stelæ are still to be seen on the barrows of the ancient Scythians and Scandinavians, though none are found crowning the sepulchral mounds of America.

endeavored to make as high a mound as possible."—(*Melpomene*, LXXI.) The richness of the Scythian barrows is extraordinary; and according to Strahlenberg, the local governors of Siberia used formerly to authorize caravans or expeditions "to visit and ransack the tombs," reserving to themselves a tenth of the treasures recovered.—(*Siberia*, p. 366.) In the second volume of the British Archæologia, is an account of the opening of one of the large tumuli in southern Siberia. After removing the superincumbent earth and stones, three vaults, constructed of unhewn stones and of rude workmanship, were discovered. The central one was largest, and contained the remains of the individual over whom the tumulus had been erected. It also contained his sword, spear, bow, quiver, arrows, etc. In the vault at his feet, were the skeleton and trappings of a horse; in the vault at his head, a female skeleton, supposed to be that of his wife. The male skeleton reclined against the head of the vault, on a sheet of pure gold, extending from head to foot, and another of like dimensions was spread over it.. It had been wrapped in a rich mantle, studded with rubies and emeralds. The female skeleton was enveloped in like manner: a golden chain of many links, set with rubies, went round her neck, and there were bracelets of gold upon her arms. The four sheets of gold weighed forty pounds.

In some instances, the bodies were burned before interment. All of the Scythian barrows contain numerous relics of art, ornaments of gold and silver and precious stones, weapons and implements of war, domestic utensils, mirrors, images and idols, vases of metal and pottery, grains of the millet kind, etc., etc.—(*Strahlenberg*, pp. 264, 268; *Rennel's Herodotus*, p. 110.)

These ancient tombs, which are called *Bogri* by the Russians, are often plain mounds. Some were set round with rough stones in a circle or square: others with hewn stones. In the squares the corner-stone was usually higher and broader than the others, and sometimes bore inscriptions. Occasionally, the barrow was surmounted with a stone, or *stela.*

In Rajast'han, the practice of burying the distinguished dead under tumuli still exists. Previous to interment, the body is burned, as is also the wife of the deceased, who in all cases accompanies her lord. Monumental pillars are also erected, rudely carved with emblematic figures. They are placed in lines, irregular groups, and in circles, and are numerous in the vicinity of every large town. These tombs are places of sacrifice, and to them the Rajpoot repairs at stated intervals, to make offerings to the manes of his ancestors.—(*Tod's Rajast'han*, Vol. I., pp. 72, 75.)

A singular variety of tumular structures, maintaining a certain resemblance to those of other portions of the globe, but having many essentially peculiar features, is found in Sweden. They are, for the chief part, circular: sometimes, however, there is a square enclosure of upright stones, with a conical barrow in the centre, which has its base surrounded with upright stones; midway between this and the summit, the circumference is marked by a second ring of upright stones; close to the summit, a third belt encircles it, and the crest of the barrow is crowned by a *cromlech*, or group of stones. Another variety has a circle of upright stones around the base of a *carnedd*, or stone mound. A third variety has a circular belt of upright stones around a conical barrow, which is surmounted by a single upright

stone. In connection with these, is a remarkable variety of stone enclosures. Some consist of a simple circle of upright stones; two of which, placed opposite each other, are larger and taller than the rest. Others are circular, with a small avenue of approach of four stones on each side; others are large circles, with every sixth stone of larger size than the others, and the two north and south, of still greater dimensions; others are triangular, with a large stone in the centre, and another at each corner; others triangular, with each side curving inward, but without the large stones in the centre and corners; others are square. The structures last named are frequently surrounded by *valla*, and enclosures are seen contiguous to and even forming part of tumuli.—(*Sjoborg Samlingar for Nordens Fornälskare, &c.*, 2 Vols. 4to., *Stockholm*, 1822; *Zur Alterthumskunde des Nordens, Von J. J. A. Worsaæ, Leipzig*, 1847.)

Mr. Worsaæ divides these barrows, according to the character of their contents, into three classes:

First.—*Barrows of the Stone Age.*—These contain unburned corpses, enclosed in rude stone chambers: the implements and utensils found in them are of stone or flint.

Second.—*Barrows of the Bronze Age.*—Containing burned human remains, deposited in vases or little stone chests: also, arms and utensils of bronze or copper.

Third.—*Barrows of the Iron Age.*—Burned human remains: arms and utensils of iron, etc. These barrows are often of regular forms, triangular, square, oval, shipform, etc.; generally surrounded by upright stones, as above.

This classification differs somewhat from that usually adopted, in which the "age of fire" and the "age of hills" distinguish the earlier and later periods of Scandinavian monumental history. Odin is said to have introduced the practice of burning, and also that of the wife sacrificing herself with her deceased lord.*—(*Mallet's Northern Antiq.*, Chap. XII.) Among all the rude nations of the north and west of Europe, for an indefinite period before the dawn of civilization, burial customs, strictly analogous to those already described, existed. The dead were buried with or without burning, and with them were deposited numerous relics of art, which, in the greater or less skill which they exhibit, mark the eras of burial, and the gradual advance of the builders. The Germans, says Tacitus, "added to the funeral pile the arms of the deceased and his horse," and both Cæsar and Pomponious agree in saying that the inhabitants of Belgium and Gaul buried or burned with the dead whatever was valued by them in their lifetime.

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* A recent Stockholm paper has the following paragraph relating to the excavation of certain Runic barrows, in Sweden:

"The crown Prince has lately directed several of the Runic Barrows, or 'giant's graves,' in the neighborhood of old Upsula, to be opened at his cost. Odin's Hill was the first opened, when clear proofs were found that the hill was not formed by nature, but by human hands, although the urn, with the bones of the individual inhumed therein, and which, in all probability, is in the centre of the hill, had not been found. A hearth, formed of extraordinary large bricks, was first discovered in the interior, and at a distance of about twenty-three yards, a strong wall, of large pieces of granite, resting on a solid floor made of clay; the wall formed the corner of a large grotto of from four to six feet in height. Within it there were ashes and other traces of fire. Unfortunately, the advanced period of the year has, for the present, interrupted the works, but they will be resumed in the summer."

The burial-mounds of the ancient Britons, both of the Celtic and Saxon periods, evince similar practices on the part of their builders. For obvious reasons, the mounds of the United States have oftenest been compared to these; and, upon the narrow basis of certain coincidences in structure, a common origin has been ascribed to both. This circumstance, in connection with others, justifies a more detailed notice of the British barrows than would otherwise be required. They have been systematically investigated by many learned and indefatigable antiquarians, the result of whose inquiries, so far as they relate to the modes of interment practised by the ancient inhabitants, are compendiously presented by Sir R. C. Hoare, in his splendid work, entitled "Ancient Wiltshire."

"Four distinct modes of interment were practised by the ancient Britons:—

1. The body placed generally in a cist, with its legs bent up towards the head, and frequently accompanied by daggers of brass, drinking cups, &c.

2. The body extended at full length, accompanied by articles of brass and iron, such as spear-heads, lances, swords, and the umbos of shields.

3. Interment by incremation: when the body of the deceased was consumed by fire, and the bones and ashes deposited either on the floor of the barrow, or in a cist cut in the chalk. This is called a simple interment.

4. Urn burial, with incremation, when the body was burned, and the bones and ashes deposited within a sepulchral urn, which is generally, though not in all cases, reversed. By the web of cloth still remaining in some instances, it appears that the ashes were wrapped up in a linen cloth and fastened by a small brass pin, several of which, intermixed with the ashes, have been found.

"Of these modes of burial, the first was probably most primitive: articles of iron bespeak a later period; and it is further probable, that the two modes of burying the body by fire were adopted at one and the same period. We have instances where the body has been enclosed in a wooden chest, riveted with brass, or within the more simple covering of an unbarked timber tree."

A very remarkable resemblance in form exists between the various kinds of British barrows and the mounds of this country; in this respect, indeed, there is scarcely a perceptible difference between them. The curious will find in Hoare's Ancient Wiltshire, 1812; Stukeley's Stonehenge and Itinerarium; Rowland's Antiquities of Anglesey, 1723; Camden's Britannia; Grose's Antiquities; in the British Archæologia, thirty volumes, quarto; Higgins's Celtic Druids, 1827; Borlase's Ancient Cornwall; and in numerous other works upon the subject, abundant illustrations of the correctness of this observation. Sir R. C. Hoare has attempted to make the variety of form exhibited by these barrows the basis of a classification, distinguishing the eras of their construction, and even the caste and condition of the dead which they cover. It is probable that some varieties of form may have predominated at a particular period, and that the dimensions of the barrow may have, in some degree, corresponded with the rank of the dead. Further than this, however, the theory is not well sustained. Sir Richard enumerates not less than eleven kinds of tumuli, distinguished from each other by their form, viz:—

1st. *The Long Barrow*, which resembles half an egg, cut lengthwise, one end

a little broader than the other, generally ditched around the base, sometimes enclosed in a circle, and occasionally set round with upright stones. Supposed to be the oldest form of the Celtic barrows. *Contents:* usually a number of skeletons at the broad end, lying in a confused manner, and generally covered with a pile of stones or flints. In other parts, stags' horns, fragments of rude pottery, and burnt bones.

2d. *The Bowl Barrow*, the form of which is indicated by the name, with or without a ditch, and having a slight depression in the top. Supposed to be a family mausoleum.

3d. *The Bell Barrow*, a modification of the *Bowl Barrow*, supposed to have been formed by placing a new top thereon, for additional interment.

4th. *The Druid Barrows*, enclosed by a vallum and ditch, the latter always interior to the former; the number of mounds within the enclosure varying from one to fifteen or twenty. *Contents:* skeletons, small cups, beads of amber, glass, and jet, small lance-heads, and, very rarely, sepulchral urns, all of elegant workmanship. Sir Richard supposes, from the predominance of ornaments, that they were devoted to females. Supposed to be family cemeteries.

5th. *The Pond Barrow*, consisting of a simple circular vallum or ditch. Fosbroke doubts whether these should be denominated barrows, and suggests that they may have been Druidical tribunals. They are identical in form with many of the small circles of the West. No remains found in them.

6th. *The Twin Barrow*, comprised of two barrows joining each other, and enclosed in a circle. Supposed by Sir Richard to be the monuments of individuals closely allied to each other by blood or friendship.

The remaining classes are but slight and hardly appreciable modifications of those already described.

The rude natives of New Zealand erect tumuli over their dead, who are sometimes burned previous to interment. Their arms and ornaments are deposited with them. Custom rigorously enjoins that these monuments to the departed shall be carefully watched over. A woman at Clarence River, who neglected to weed and trim her husband's tumulus, was put to death in consequence of her neglect.—(*Angas' Australia and New Zealand*, Vol. II., p. 280; *Gray's Australia*, Vol. I., p. 227.) Similar monuments, most usually constructed of stone, and sometimes of great size and regularity, were often erected over the dead, by the natives of the larger Polynesian Islands, where they still remain, enduring records of the primitive customs of the islanders.—(*Ellis's Polynesian Researches*, Vol. III., pp. 242, 325; *Beechey's Nar.*, pp. 20, 37; *La Pérouse Voy.*, Vol. III., p. 194.)

Without noticing further the burial customs of nations, ancient and modern, in the various quarters of the globe, enough has been presented to show the general prevalence of mound-sepulture, and the nearly uniform practices which attended it. As remarked at the outset, it is the simplest method of perpetuating the memory of the dead. Its general adoption by different and widely separated people, must not, therefore, be taken to indicate any extraordinary dependence.

PROBABLE FUNERAL RITES OF THE MOUND-BUILDERS.

From various features discovered in the sepulchral mounds of the West, it has been suggested that sacrifices or ceremonies of some kind, in which fire performed a part, were solemnized above the dead. The general occurrence of a layer of charcoal at some point near the surface of the mound, bearing evidence of having been heaped over while burning, and sometimes having mingled with it human bones, the bones of animals, and relics of art, affords ample basis for the conjecture. We have seen that in the burials of Chili, sacrifices and libations were made at the tumuli of the dead; in Peru, the burial rites were very similar, and in cases where the deceased was of the Inca race, or a person of consequence, his wives and domestics were put to death, that they might accompany and serve him in another world. On the death of the Inca Huyana Capac, it is said that over one thousand victims were slain at his tomb. Similar practices prevailed among many of the South American savage tribes; also in Central America and in Mexico. In the latter country, the arms, implements, and ornaments of the deceased were burned or buried with him; and, as we have already said, an animal resembling a dog, called by the Mexicans *techichi*, was killed, to accompany his soul in its journey to the world of spirits. If the body was burned, the ashes were collected in an earthen pot; in this was deposited a gem, which it was supposed would serve in the next world for a heart; and the urn was buried in a deep ditch.* Eighty days thereafter, oblations of meats and drinks were made over the grave. On the decease of persons of consequence, their slaves and servants were put to death; sometimes in great numbers. Analogous customs prevailed among the Natchez, when, on the death of the Suns, many human victims were sacrificed. Among the savage North American tribes, no custom was more general than that of making oblations at the tombs of the dead: dogs were sometimes sacrificed at the burial; and horses are now occasionally slain by the Western tribes, upon the graves of their owners.

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* "They (the Mexicans) made it the office of the priests to inter the dead and perform the funeral obsequies. They buried them in their own gardens, and in the courts of their own houses. Some were carried to the places of sacrifice in the mountains; others were burnt, and the ashes afterwards buried in the temples; and with all were buried whatever they had of apparel, stones, and jewels. They did put the ashes of the dead in pots, and with them their valuables, how rich soever they might be. If it were a king or lord who was dead, they offered slaves to be put to death, and gave apparel to such as came to the interment. * * * They did set food and drink on the graves of the dead, imagining that their souls did feed thereon."—(*Acosta in Purchas,* Vol. III., p. 1029.)

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Libations in some cases were made at the tomb, and repeated at intervals for years. According to Charlevoix, at the "Feasts of the Dead," or general burial of the Hurons and Iroquois, dances, games, and combats constituted part of the ceremonies of the occasion.

Vanegas (*Hist. California*, I., p. 104) says, The California Indians bury or burn their dead indifferently, as chances to be most convenient. Vancouver (*Voy*. III., pp. 182, 242) mentions two instances, in which the natives of the Northwest coast burned their dead; but we are not left to infer that the custom was general. A singular funeral custom is mentioned as prevailing among the *Takali*, or Carriers, one of the Oregon tribes, and a branch of the great Algonquin family. They always burn their dead upon a pyre; in case the deceased has a wife, she is obliged to lie by the side of the corpse until the fire is lighted and the heat becomes intense. If, in the estimation of the spectators, she abandons the pyre too early, she is thrust back, and thus often falls a sacrifice. The Medicine-men of this tribe pretend to receive the spirit of the dead in their hands, after the corpse is burned, and to be able to transfer it to any one they choose, who then bears the name of the dead, in addition to his own.—(*Narrative of U. S. Exploring Expedition*, Vol. IV., p. 453.)

Father Creux, a Jesuit Missionary in Canada, in 1639, notices a fact which affords a curious antithesis to the customs of the Mexicans, above presented by Clavigero: namely, that the Hurons cut off the flesh from the bones of those who were drowned or frozen, and burned it; the skeleton alone was buried. Charlevoix (Vol. II., p. 189) confirms this statement. He adds, that the bodies of those slain in battle were burned, probably for the more easy transportation of their ashes to the burial-grounds of their fathers.

La Hontan (Vol. II., p. 53) states that "The savages upon the Long River [Mississippi?] burn their dead; reserving the bodies until there are a sufficient number to burn together, which is performed out of the village, in a place set apart for the purpose." This statement does not find support in other authorities.

"They appease the souls of the dead with offerings of meats and drinks. Every woman whose child dies at a distance from home, makes a journey, once a year, if possible, to its place of burial, to pour a libation on its grave."—(*Loskiel*, p. 76.)

With these facts and the suggestions of analogy before us, we are certainly justified in the inference that the burials in the mounds were attended with sacrifices, perhaps of human victims, with oblations, and, it is probable, with games and ceremonies corresponding with those which prevailed, at one period, in the Old World.

It was remarked, in a preceding chapter, that the highest points of the hills and the jutting bluffs of the table-lands bordering the valleys of the Western rivers, are often crowned with mounds. Although generally supposed to have been designed for "look-outs," or places of observation, investigation has shown that a portion of them, at least, were sepulchral in their original purposes. Clavigero observes of the Mexicans, that they had no particular places assigned for the burial of their dead, but entombed them in the fields and on the *mountains*. It is possible that an ambition like that which governed the selection of the place of

sepulture of the Omahaw chief, Blackbird, also influenced the ancient people in the disposal of their dead. He was buried sitting on his favorite horse, on the summit of a high hill overlooking the Mississippi, "that he might see the strangers coming to trade with his people."* So, too, the chiefs of the mound-builders may have desired, at their death, to be placed where, with the eyes of a spirit, they might watch over their people thronging the fertile valleys beneath their tombs. Thus an early Greek poet speaks of the tomb of Themistocles overlooking the Piræus:

> "Then shall thy mound, conspicuous on the shore,
> Salute the mariners who pass the sea,
> Keep watch on all who enter or depart,
> And be the umpire in the naval strife."
> *Plato comicus, ap. Plut. vit. Themist.*

A somewhat similar sentiment occurs in the Iliad, where Hector, speaking of one he is to slay in single combat, says:

> "The long-haired Greeks
> To him, upon the shores of Hellespont,
> A mound shall heap; that those in after-times
> Who sail along the darksome sea shall say,
> 'This is the monument of one long since
> Borne to his grave, by mighty Hector slain.'"

The ancient Anglo-Saxon was not without a similar ambition. The dying Beowulf enjoins:

> "Command the famous in war
> to make a mound,
> bright after the funeral fire,
> upon the nose of the promontory.
> Which shall for a memorial
> to my people
> rise high aloft
> on Hronesness;
> that the sea-sailors
> may afterwards call it
> Beowulf's barrow,
> when the Brentings
> over the darkness of the floods
> shall sail afar."—*Beowulf*, v. 5599.

The size of the aboriginal mounds of the West was no doubt regulated in a degree by the dignity of the individuals over whose remains they were erected, or by the regard in which they were held by their people. In the number or value of their enclosed relics, the various mounds, great and small, exhibit little difference. We have, however, seen, according to Ulloa, that the character of the deposites

* Kemble, in a note to Beowulf, quotes an Icelandic Saga describing the ceremonies attending the burial of a hero, as the death-feast, the raising of the mound, the casting of treasures therein, the slaughter of his horse, and the placing of the hero in his chariot.

as well as the size of the mound was, in Peru, a sure indication of the state and power of the dead. Such was the case among the ancients. Beowulf requests that his people may raise a barrow over him proportionate in size to the respect entertained for his memory:

"Old of life, he spake a whole multitude of words, and commanded me to greet you; he bade that ye should make, according to the deeds of your friend, on the place of the funeral pile, the lofty barrow, large and famous, even as he was of men the most worthy warrior."—(*Beowulf*, I., 6183.)

In the subsequent burial of Beowulf, the burning of the body, the sacrifices, the games, the songs and orations in praise of the dead and in commemoration of his deeds, we have a vivid picture of the funeral customs of the olden time,—customs not peculiar to the old Continent, but prevailing among the nations of the New World, and probably attending the burials of the ancient people whose monuments we are investigating. Beowulf's people carry into effect his desire, and the poem ends with this description of his interment:—

"For him then prepared the people of the Geats a funeral pile upon the earth, strong, hung round with helmets, with war-boards (shields), and with bright byrnies, as he had requested. The heroes, weeping, then laid down in the midst the famous chieftain, their dear lord. Then began on the hill the mightiest of funeral fires the warriors to awake: the wood-smoke rose aloft dark from the fire; noisily it went, mingled with weeping. The mixture of the wind lay on till it the bone-house [body] had broken, hot in his breast. Sad in mind, sorry in mood, they mourned the death of their lord. * * * Made then the people of the Westerns a mound over the sea; it was high and broad, by the sailors over the waves to be seen afar. And they built up, during ten days, the beacon of the war-renowned, the [king] of swords. They surrounded it with a wall, in the most honorable manner that wise men could desire. They put into the mound rings and bright gems, all such ornaments as the fierce-minded men had before taken from the hoard: they suffered the earth to hold the treasures of warriors, gold on the sand; there it yet remaineth, as useless to men as it was of old. Then round the mound rode of beasts of war, of nobles, a troop, twelve in all; they would speak about the king, they would call him to mind, relate the song of words, speak themselves; they praised his valor, and his deeds of bravery they judged with honor, as it is fitting that a man his friendly lord should extol, should love him in his soul, when he must depart from his body to become valueless. Thus mourned the people of the Geats, his domestic comrades, their dear lord; they said that he was of the kings of the world the mildest of men and the most gentle, the most gracious to his people, and the most jealous of glory."—(*Beowulf*, v. 6268.)

THE MOUNDS NOT GENERAL BURIAL-PLACES; GREAT INDIAN CEMETERIES OF THE WEST.

ALLUSION has been made, in the body of this work, to the large cemeteries which have been discovered at various places in the Mississippi valley, and the suggestion ventured that they owe their origin to practices similar to those which prevailed among the Indians of New York and Canada, of collecting, at stated intervals, the bones of the dead, and depositing them in pits or trenches. There are many interesting facts connected with these cemeteries, which merit attention, and justify a recurrence to the subject.

Nothing is more common in the accounts given of Western mounds, than the loose and very vague remark, that certain ones or all of them "contain vast quantities of human bones." To this circumstance seems attributable, in a great degree, the prevailing and very erroneous impression, that the mounds are simple tombs, or rather grand cemeteries, containing the remains of an entire race. The Grave Creek mound is spoken of by Atwater, Doddridge, and other writers, as a grand mausoleum "undoubtedly containing many thousand human skeletons." An investigation has shown it to contain but a very few skeletons; and examinations of several other tumuli, characterized in similar extravagant terms, have been attended with like results. *The mounds of the West can be regarded only to a very limited extent as the burial-places of the people who built them.* But little more than one-half of their number are clearly sepulchral in their character; and these, except in extraordinary cases, contain but a single skeleton each.*

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* The authority of Mr. Samuel R. Brown, author of the "Western Gazetteer, or Emigrant's Directory," published in 1817, has been quoted by various writers on American antiquities, and has been supposed to sustain the conclusion that the mounds were vast receptacles of the dead, slain in battle. It will be seen, however, from Mr. Brown's account of his explorations, that the mounds which he examined contained *deposites of different dates*, one of which was clearly of the modern Indians, though the fact does not appear to have suggested itself to the mind of the explorer, or to have occurred to the writers who have followed him. The material portions of Mr. Brown's account are subjoined:

"We examined from fifteen to twenty of these mounds. In some, whose height was from fifteen to twenty feet, we could not find more than four or five skeletons. In one, not the least appearance of a human bone was to be found. Others were so full of bones as to warrant the belief that they originally contained at least one hundred bodies; children of different ages and the full grown seemed to have been piled together promiscuously. * * * In the progress of our researches, we obtained ample testimony that these masses of earth were the work of a savage people. We discovered a piece of glass resembling the bottom of a tumbler, but concave; several stone axes, etc. * * * There was no appearance of *iron;* one of the skulls was found pierced by an arrow, which was still sticking in it, driven about half way

We must seek elsewhere for the general depositories of the dead of the mound-builders. It has been suggested that the caves of the limestone regions of Kentucky and Tennessee were used as sepulchres. Some of these are represented to have contained thousands of bodies, preserved by the natural properties of these caves, clothed in strange fabrics, composed of a coarse species of cloth interwoven with feathers, in fanciful and tasteful patterns, resembling the feather-cloth of Mexico, of which such glowing descriptions were given by the conquerors.* Extensive, however, as these cave depositories may have been, they fail, in view of

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through before its force was spent. It was about six inches long. The subjects of this mound were doubtless killed in battle and hastily buried. In digging to the bottom of them, we *invariably* came to a stratum of ashes, from six inches to two feet thick, which rests on the original earth. These ashes contain coals, fragments of brands, and pieces of *calcined bones*. From the quantity of ashes and bones, and the appearance of the earth underneath, it was evident that large fires must have been kept burning for several days previous to commencing the mound, and that a considerable number of victims must have been sacrificed by burning on the spot."—(*Brown's Gazetteer of the West*, p. 58.)

"That some of the mounds served for tombs, we have the conclusive evidence that they abound in human bones. It has often been asserted, that some of the mounds are full of bones that are perforated, as though the living subjects were slain in battle; and that the skeletons are heaped together in promiscuous confusion, as if buried after a conflict, without order or arrangement. The bones which we have seen were such, and so arranged, as might be expected in the common process of solemn and deliberate inhumation."—(*Flint.*)

"The vulgar opinion has been circulated by various writers, that under these mounds were buried the bodies of those who were slain in battle. They probably pertained to the particular tribe of a country, and were restricted to the principals among them; for it is not to be supposed that the inhabitants were indiscriminately buried under tumuli. Their burial-places must be sought elsewhere."—(*Sir Richard C. Hoare, on the Barrows of Great Britain.*)

* The nitrous caves of Kentucky were found to contain a considerable number of desiccated human bodies; they were termed *mummies*, and, for a time, created much speculation. They were generally enveloped in skins, in a species of bark, or in feather-cloth, and placed in a squatting posture. It is said that hundreds of these were taken from a cave near Lexington, and burned by the early settlers. The bodies appear to have owed their preservation entirely to natural causes. It has been inferred, from the resemblance between the envelopes of these bodies and the feather-cloths of Mexico, that the people who thus deposited their dead were very ancient, and probably an offshoot from Mexico. We have, however, abundant evidence to show that fabrics of this kind were manufactured by the Southern Indian tribes. The chronicler of Soto's expedition reports having found "a great many mantles made of white, red, green, and blue feathers, very convenient for the winter." Du Pratz also describes this feather fabric as of common use; and Adair observes: "They likewise make turkey-feather blankets, twisting the inner end of the feathers very fast in a double, strong thread of the inner bark of the mulberry," etc.—(*Am. Inds.*, p. 423.)

In May, 1835, a cavern cemetery was discovered on the banks of the Ohio River, opposite Steubenville. It was thirty or forty feet in circumference, and filled with human bones. "They were of all ages, and had been thrown in indiscriminately after the removal of the flesh. They seemed to have been deposited at different periods of time, those on the top alone being in a good state of preservation."—(*Morton's Crania Americana*, p. 235.) Dr. Morton regards these remains as of no great age, and as undoubtedly belonging to individuals of the barbarous tribes.

A similar cave was discovered, some years ago, at Golconda, on the Ohio River, Illinois. It contained many skeletons.—(*Crania Am.*, p. 234.) Henry, in his travels, mentions a cave in the island of Mackinaw, in Lake Huron, the floor of which was covered with human bones. He expresses the opinion that it was formerly filled with them. The Indians knew nothing concerning the deposite; our author, nevertheless, ventures the conjecture, that the cave was an ancient receptacle of the bones of prisoners sacrificed at the Indian war-feasts. "I have always observed," he continues, "that the Indians pay particular attention to

the abundant evidences of a vast ancient population, to answer the question, What became of the dead of the ancient people? In Tennessee, as well as in Kentucky and Missouri, extensive cemeteries have been discovered. For a description of some of those of Tennessee, the public are indebted to Prof. Troost, of Nashville. —(*Trans. Am. Ethnol. Soc.*, Vol. I., p. 358.) One is mentioned by him in the immediate vicinity of that town, which is about a mile in length, and of indefinite breadth. No less than six others equally extensive are found within a radius of ten miles. The graves are lined with flat stones, and occur in ranges. Within these, skeletons much decayed are found, also various relics, some of which are recognised as identical with those found in the mounds of Ohio, suggesting a common origin. This identity is further indicated, though not established, by the presence of mounds and other structures in the vicinity of these cemeteries. Beads, composed of perforated shells, of the genus *Marginella*, were discovered by Dr. Troost in the graves. These have been found in both the sepulchral and sacrificial mounds north of the Ohio; as have also beads and other ornaments, made probably from the columella of the *strombus gigas*, similar to those found by this explorer in the graves above mentioned. How far these coincidences may be traced, can only be determined when the same mind which has investigated one class of remains shall be able to investigate the other.

Near Sparta, in Tennessee, are several extensive cemeteries, in which the bones of the dead were deposited, enclosed in short coffins or boxes, made of flat stones. These coffins measure about two feet in length and nine inches in depth. A small, rude, earthen vessel, accompanied by some small shells, is usually found near the head of each skeleton.—(*Featherstonhaugh's Trav.*, p. 48.) Similar burial-places are found in Missouri, particularly in the vicinity of the Marimec River. The

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the bones of sacrifices, preserving them unbroken, and depositing them in some place exclusively appropriated to the purpose."—(*Travels*, p. 111.)

In the State of Durango, Mexico, some cave depositories have been discovered, which have given rise to very exaggerated accounts. Some of them have represented that as many as a million of bodies were found in a single cavern. All the information which we have, that can be regarded as authentic, is contained in Dr. Wislizenus's Memoir of the Expedition under Doniphan, published by order of Congress, p. 69. After crossing the Rio Nasas, we arrived at San Lorenzo. "On the right hand, or south of us, was a chain of limestone hills running parallel to the road. At the foot of a hill belonging to the chain, Señor de Gaba pointed out a place to me where, some years ago, a remarkable discovery had been made. In the year 1838, a Mexican, Don Juan Flores, perceived the hidden entrance to a cave. He entered, and found nearly one thousand well preserved Indian corpses, squatted together on the ground, with their hands folded below their knees. They were dressed in fine blankets, made of the fibres of lechuguilla, with sandals made of a species of liana, and were ornamented with colored scarfs, with beads of seeds of fruits, polished bones, etc. This is a very insufficient account of this mysterious burying-place. The Mexicans supposed it belonged to the Lipans, an old Indian tribe which from time immemorial has roved and still roams over the Bolson de Mahimi. I had heard at Chihuahua of this discovery, and was fortunate enough to secure a skull which had been taken from the cave."

Among the South American nations, cave-burial seems to have been common. Humboldt describes a cave-sepulchre of the Atures, which he discovered on the sources of the Orinoco. It contained nearly six hundred skeletons, regularly arranged in baskets and earthen vases. Some of the skeletons had been bleached, others painted, and all, it is worthy of remark, had been deposited after the removal of the flesh.

" coffins" are neatly constructed of long flat stones, planted vertically, and adapted to each other edge to edge, so as to form a continuous wall. At either end of the grave the stones project a little above the surface. These stone sarcophagi are usually from three to four, but sometimes as many as six feet in length. The bones in these appear to have been deposited after having been separated from the flesh, in accordance with a practice well known to have been common amongst many Indian tribes.—(*Beck's Gaz. of Missouri*, p. 274; *James's Exped.*, Vol. I., p. 55.) Other extensive cemeteries are found in various parts of the country. One near Alexandria, in Arkansas, is said to be a mile square.*

A very extensive cemetery has been discovered in Bracken county, Kentucky, occupying nearly the whole of the "*bottom*" or plain, on the south bank of the Ohio, between Bracken and Turtle creeks. The village of Augusta has been built upon it in latter times. The following account of this cemetery was communicated to the author by Gen. John Payne, of Augusta. It will be observed that iron was discovered in some of the graves; which demonstrates that a portion of the burials took place since communication was established between the whites and Indians, and very likely within the 18th century.

"The beautiful bottom upon which it stands, extends from one creek to the other, about a mile and a half, and averaging about 800 yards wide. The town is laid off at the upper end of the bottom. The hill back of it is high, but not precipitous; and upon arriving at the summit, it almost immediately falls towards the south with a gentle but deep descent, and immediately there rises another hill. I am thus particular, that you may have a knowledge of the ground where now rest the skeletons of hundreds, perhaps thousands, of an ancient race, as well as of the surrounding localities. The soil of the bottom-land is alluvial.

"The village rests upon one vast cemetery: indeed, the whole bottom appears to have been a great burying-ground; for a post-hole can hardly be dug in any part of it without turning up human bones, particularly within three or four hundred yards of the river bank. The ground appears to have been thrown up into ridges, one end resting on the river bank, and the other extending out some two, others three hundred yards, with depressions between of about one hundred feet, the ridges rising to an elevation of about three feet, and are about fifty or sixty yards wide. These ridges are full of human skeletons, *regularly buried*. My house, at the lower end of the village, stands upon one of these ridges: and in excavating a

* Accounts of a number of these ancient cemeteries are given by Gen. Lewis Collins, in his recently published History of Kentucky, from which the following notices are condensed. Six miles N. E. of Bowling Green, Warren county, there is a cave which has a perpendicular descent of about thirty or forty feet. At the bottom are vast quantities of human bones.—(p. 541.) On the north bank of Green River, in the vicinity of Bowling Green, are a great many ancient graves; some of which are formed of stones set edgewise. A similar cemetery occurs near the mouth of Peter's creek, on Big Barren River; the bones are enclosed in stone coffins, which are about three feet long, and from one to one and a half wide. On the same river, three miles above Glasgow, and on Skegg's creek, five miles S. W. of the same place, are caves containing human bones; those in the last named cavern seem to be exclusively the bones of small children.—(p. 177.) Similar caverns are found in Union and Meade counties, all of which are said to contain human bones in abundance.

foundation for the basement story, seventy by sixty feet, and four feet deep, we exhumed one hundred and ten skeletons, numbered by the skulls; but there were several more, the skulls of which were so much decayed and intermingled with others that I did not take them into the calculation. I have no doubt that there were at least one hundred and forty bodies buried within the bounds above mentioned; and then on every side the skeletons had been severed, a part taken away while the remains were left sticking in the wall. My garden, extending one hundred and fifty feet back from my house, is manured with human bones, and is very productive. I cannot turn up a spadefull of earth without disturbing the remains of the ancient dead.

"Those exhumed by me, I have said, appeared to have been regularly buried; they were about two feet below the surface generally, but some not more than a foot or eighteen inches, invariably with their heads toward the river—the river at this point running south 70° west; some had rough unhammered stones extending on both sides the full length, with a head and foot stone, and a stone covering the head; others, again, would have only a stone on each side of the head, a head and foot stone, and a stone covering the head; others, only a head and foot stone; and others, and much the greatest number, had 'nothing to mark the ground where they were laid.' Most of the bones were entire; but when exposed to the atmosphere, many soon crumbled into dust, though others remained quite firm. Several of the skulls, in a good state of preservation, I had in my house for months, until they were broken up. The teeth appeared sound: I do not recollect an instance of defective teeth; there were many absent teeth, but this evidently arose from their dropping out after burial. There were some skeletons of children: the bones of those mouldered into dust almost immediately.

"Many articles of Indian ornament, use, and warfare were excavated, such as arrow-heads of flint and bone, glass beads, and that peculiar kind of ancient Indian pottery, formed of clay and pulverized or pounded muscle-shells, which had evidently received the action of heat to harden it. Some of the specimens of the latter were very perfect, with well formed ears, like our pottery ware; some well formed, handsome stone pipes, glass beads, both black and blue, ornaments of bone, etc. The other ridges, where they have been opened, have exhibited like results: they are full of human bones, apparently regularly buried; but the skeletons have not been always found to lie at right angles with the river, but sometimes parallel, and at other times diagonally. Upon this bottom, and covering these remains in 1792, when the bottom was first settled, stood some of the largest trees of the forest. We have sycamores now standing on the bank, between these remains and the river, five feet in diameter at the stump.

"There is another fact which perhaps I should mention. Maj. Davis, who owned a farm on the Augusta bottom, about half a mile below the village, passing opposite his lands where a part of the bank had fallen into the river, discovered a bone sticking out of the bank; and upon drawing it out, it proved to be the bone of the right arm, and upon the wrist there were *three hammered iron rings*. They were evidently of manufactured iron, round and formed to fit the wrist: the ends brought together but not welded or closed; the iron was destroyed,—it had been so

completely oxydized as to break very easily; the workmanship was rough, and the print of the hammer was upon them.

"A full cart-load of bones, taken from the basement story of my house, I had wheeled off into my garden: over them I erected a mound, and crowned it with a summer-house; and there they shall rest for the future.

"About forty years ago, Dr. Overton, then of Lexington, was upon a visit to Augusta. I had heard of a large pile of stones upon the spur of a hill overlooking the Ohio, about three miles above. We went to visit it, worked hard nearly all day, and, at the depth of about five feet in the centre of the pile, found about a half bushel of charcoal and ashes; this was all that we could discover.

"I know of no fortifications, nor of any mounds or tumuli, in the county of Bracken. At Claysville, near the bank of Licking River, there is a very large mound; but I have not been informed that either curiosity or scientific research has induced the citizens to open it."

Cemeteries, analogous to those in Tennessee and Kentucky, as already observed, exist in Ohio. One, in the extreme northeastern part of the State, at Conneaut, on Lake Erie, covers about four acres. "It is in the form of an oblong square, and appears to have been laid out in lots running north and south, and exhibits all the order and propriety of arrangement deemed necessary to constitute Christian burial. The graves are distinguished by slight depressions, disposed in straight rows, and were originally estimated to number from two to three thousand. Some were examined in 1800, and found to contain human bones, blackened by time, which, on exposure, crumbled to dust. On the first examination of the ground by the early settlers, they found it covered with a primitive forest. A number of mounds occur in the vicinity. The pioneers observed that the lands around this place exhibited signs of having once been thrown up in squares and terraces, and laid out in gardens."—(*How's Gaz. of Ohio*, p. 40.)

A cemetery also occurs in Coshocton county, in the same state, which is described by Dr. Hildreth of Marietta, in Silliman's Journal of Science and Art. It is situated a short distance below the town of Coshocton, on an elevated, gravelly alluvion; in 1830, it covered about ten acres. The graves were arranged regularly in rows, with avenues between them; and the heads of the skeletons were placed to the west. Traces of wood were observed around some of the skeletons; from which circumstance it is supposed the bodies were deposited in coffins. The interments had evidently been what may be denominated *bone burials*, and were not made until after the decomposition of the flesh. The graves, consequently, measure but little more than three feet in length, the bones being dismembered and packed upon each other, or flexed together, thus giving rise to the popular error of an aboriginal *pigmy race*. No relics are described as accompanying the human remains.* Near this cemetery is a large mound.

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* It is said that in one of the graves were found pieces of oaken boards, together with some wrought iron nails. If such were the fact, the burial must have been made subsequent to the commencement of European intercourse. It is possible that this was a burial of later date than the others.

How far these cemeteries may be regarded as the depositories of the mound-builders, we are unprepared to say. Dr. Troost is disposed to regard the "pigmy graves" as of comparatively late origin, and distinguishes between them and the cemeteries of the more ancient race. He observes: "Some consider these places as battle-grounds, and the graves, those of the slain; but that is not the case. The Indians do not bury fallen foes: they leave them to be devoured by wild animals; their own slain they carry to their towns, or hang up in mats, on trees. They have their burying festivals, when they collect the bones thus preserved, and bury them. In my opinion, the numerous small graves which are attributed to a race of pigmies, had this origin. I have opened numbers of them, and found them filled with mouldering bones, which, judging from the fragments, belonged to common sized men. The bones in these graves lay without order. This is not the case with the old extinct race, whose graves are much larger, the skeletons being generally stretched out. Nevertheless, I have found these also more or less doubled up."* It is extremely probable that the large cemeteries of Ohio, and those of Kentucky and Tennessee, had a common origin. The absence of stone coffins in the former may perhaps be ascribed to the greater difficulty of procuring stones for the purpose of constructing them. Quite a number of stone graves have, nevertheless, been found in Ohio, entirely corresponding in structure with those above described; all of which answer perfectly to the *cistvaen* or *kistvaen* of the British antiquaries.

It is the opinion of Dr. Morton, founded upon an examination of the human remains found in some of the "pigmy graves" of Tennessee, that "the so-called pigmies of the Western country were merely children, who, for reasons not readily explained, but which actuate some religious communities of our own time, were buried apart from the adult people of their tribe."—(*An Inquiry into the Distinctive Characteristics of the American Race*, p. 44.)

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* Trans. Am. Ethnog. Soc., Vol. I., p. 358. Dr. Troost describes these graves as "rude fabrics, composed of rough flat stones (mostly a kind of slaty lime and sandstone, abundant in Tennessee). These were laid on the ground, in an excavation made for the purpose: upon them were put, edgewise, two similar stones of about the same length as the former; and two small ones were put at the extremities, so as to form an oblong box of the size of a man. When a coffin was to be constructed next to it, one of the side stones served for both, and consequently they lay in straight rows, in one layer only: I never found one above the other."

The vulgar notion of a pigmy race, founded upon the small size of some of the ancient stone graves, was for a time associated with another equally absurd. Some skulls of old persons were taken from those cemeteries: the teeth had been lost and the *alveolæ* obliterated, exposing the sharp edge of the jaw bone; whence it was inferred that the ancient pigmies were destitute of teeth, and had jaws like those of a turtle!

ABORIGINAL SACRED ENCLOSURES.

It has elsewhere been observed, "that the structure, not less than the form and position, of a large number of the aboriginal enclosures of the Mississippi valley, render it certain that they were designed for other than defensive purposes."—(*Ancient Monuments of the Mississippi Valley*, p. 47) They are distinguished for their regularity: most are circular, others are square or rectangular, and a few are elliptical or octagonal. Sometimes these figures are combined in the same group. While the defensive works for the most part occupy high hills and other commanding positions, and in their form correspond to the natural features of the ground upon which they are built, the sacred enclosures almost invariably occur upon the level river terraces, where the surface is least undulating. The ditch, in the few instances where that feature is discovered, is, with rare exceptions, interior to the embankment; and, in procuring the material comprising the latter, great care seems to have been exercised by the builders to preserve the surface of the surrounding plain smooth and, as far as practicable, unbroken. The further fact that many of these regular works are commanded from neighboring eminences, not to mention the absence of supplies of water, seems conclusively to establish, that whatever may have been their secondary purposes, they were not primarily connected with any military system.

It has also been observed that these enclosures contain mounds, evidently of sacred origin. Some of them correspond in form with the ancient pyramidal temples of Mexico and Central America, and others cover altars upon which were offered the sacrifices prescribed by the aboriginal ritual.

Upon the basis of these facts, it is assumed that the enclosures of the West, not manifestly defensive in their purposes, were in some way connected with the superstitions of their builders; an assumption supported by the well known fact that the most imposing monuments of human labor and skill, in early times, were those which were erected under the influence of religious zeal.

Proceeding upon this assumption, we next inquire what relations these works sustain to the sacred structures of the various aboriginal nations of this continent, and to those erected by the primitive nations of the Old World, and to what extent they may be regarded as indicating the religious beliefs and conceptions of their builders?

TEMPLES OF THE NORTH AMERICAN INDIANS.

The temples of most of the North American Indian tribes were of the rudest character, and distinguished only by their greater size from the ordinary huts of

the natives. The ground which they occupied was considered sacred, and an area around them was sometimes enclosed and consecrated to religious rites. Like the religious structures of the Druids, they were usually places of deliberation and council; within them the priests performed the ceremonies of their religion, and within them the chiefs and warriors gathered to consult on public affairs, to make war and conclude peace. Within them also was maintained the sacred fire of those nations which adhered to the requirements of sun-worship. The Narragansett Indians of New England, and the nations of Virginia, both kept up perpetual fires in their temples, as did also the Natchez and the other tribes which assimilated to the semi-civilized natives of Central America.—(*Purchas's Pilgrims*, IV., p. 1868; *McCulloch's Researches*, p. 3; *Loskiel*, p. 39; *Catlin's N. A. Indians*, Vol. I., pp. 88, 158.) Amongst the Natchez, these temples were sometimes decorated with rude carvings and paintings, which probably were not without their significance.

Berkley describes with some minuteness a *Quioccosan* or sacred building of the Virginia Indians. It was constructed in precisely the same manner with their cabins generally, but was somewhat larger. It was thirty feet long by eighteen broad; and around and at some distance from it, were "set up posts, with faces carved on them and painted." The entrance was barricaded with logs; thus there was neither window nor passage for the light, except the door. In the centre of the building was a fire-place, and near one end was suspended a partition of mats, behind which, on shelves, were found three other mats, carefully rolled up. "In one of them," says our author, "we found some bones, which we judged to be the bones of men; in another we found some Indian tomahawks, finely graven and painted; and in the third, some materials which, when put together, formed a rude figure of a man, which was their *okee*, *kiwassee*, *Quioccos*, or idol."—(*Hist. Virginia*, p. 166.)

Smith, in his description of Virginia, says, that "in every territory of a Werowance is a temple and a priest—two or three, or more." He mentions also, "upon the top of certain red sandy hills, great houses filled with images of their kings and devils, and tombs of their predecessors. Which houses are neere sixty foot in length, built arborwise. This place they account so holy, that none but priests or kings dare come into it, nor the savages dare not go up in boats by it, but that they solemnly cast some pieces of copper, white beads, or pocones in the river. In this place are commonly resident seven priests."—(*Smith in Purchas*, Vol. IV., p. 1701.)

Marchand mentions a temple among the natives of Coxe's Channel (N. W. Coast), which had some relation to the primitive open temples of the Old World. "It is surrounded by strong posts, seven or eight feet high, in which are preserved all the tall trees that are then growing; but all the shrubs are carefully torn up, and the ground is everywhere put in order and well beaten. In the midst of this enclosure, where a cave is sometimes made, is seen a square and uncovered edifice, constructed with handsome planks, the workmanship of which is admirable; and a stranger cannot behold without admiration that they are twenty-five feet in length, by four in breadth, and two and a half inches in thickness."—(*Marchand's Voy.*, Vol. I., p. 409.) Vanegas states that there was a temple, in his day, at the

Island of St. Catherines, on the coast of California, which had a spacious level court, where the Indians performed their sacrifices. The place of the altar was a large circular space, with an enclosure of feathers of divers colors; and within the circle was an image strangely painted, representing some devil, according to the manner of the Indians of Mexico, holding in his hand the figures of the sun and the moon.—(*Vanegas's California*, Vol. I., p. 105.)

Prince Maximilian has described to us the "Medicine lodge" of the Minataree Indians, of which the subjoined engraving (Fig. 36) is a plan. It is situated in the centre of the village, and consists of an elliptical space, one hundred and

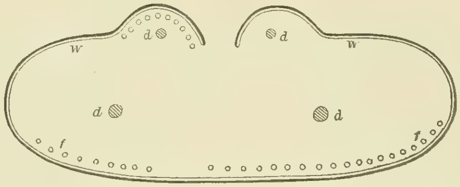

Fig. 36.

twenty feet in length, enclosed by a fence ten or twelve feet high, composed of reeds and poles, somewhat inclining inwards. It has an entrance to the left; *d*, *d*, *d*, *d*, are four fires; and in the semi-elliptical recesses, the medicine men and elders of the tribe have their seats.—(*Travels in America*, p. 419.) The place occupied by the spectators, is indicated by *f*, *f*. The Mandans had similar "medicine lodges," except that they were circular in form. They had also a sacred area in the centre of their village; and within it was placed a shrine of high mystery, around which their religious dances were performed.

It would be profitless to inquire further into the character of the sacred edifices, "medicine lodges," or "council houses" of the hunter tribes. It will be seen at once, that they reflect little if any light upon the structures under notice.

No sooner, however, do we pass to the southward, and arrive among the Creeks, Natchez, and affiliated Floridian tribes, than we discover traces of structures which, if they do not entirely correspond with the regular earth-works of the West, nevertheless seem to be somewhat analogous to them. These natives, it will be remembered, had made some slight advances in civilization, were agricultural in their habits, lived in considerable towns, had a systematized religion, and sustained many other resemblances to the semi-civilized nations of the continent.

Adair, in his account of these Indians, frequently mentions "*the Holy Square*" surrounding their temples, and within which their religious rites were performed. He does not, however, descend to particularize; and we are left to conjecture what were its dimensions, and how its boundaries were designated. It must have been of considerable size; for he several times speaks of it as receiving an entire village or tribe, at the time of the great annual festivals. He is so absorbed, however, in his favorite theory, that he cannot describe any feature except by the name borne by its fancied counterpart among the Jews. So we are not surprised in

finding, within "the Sacred Square," and standing near its western side, a *Sanctum Sanctorum*, or most holy place, enclosed by a mud-wall about breast high. It was here that the consecrated vessels of earthen ware, conch-shells, etc., were deposited. This sacred place, according to our authority, could not be approached by any but the *magi* or priests. Indeed, so great a holiness attached to the sacred squares themselves, that it was believed if the great annual sacrifice were made elsewhere, it would not only be unavailable for the purposes required, but bring down the anger of the god to propitiate whose favor it was instituted, viz., the genial god, the god of almost universal adoration amongst rude people, the fountain of heat and light, the divine fire, *The Sun!* Within this square, at least at the time of the great festival, the women were not allowed to enter, nor those persons who had neglected to comply with certain prescribed purifying ceremonies, or who had been guilty of certain specified crimes.

The deficiencies in Adair's account are supplied to a considerable extent by Bartram, in a MS. work on the Creek Indians, now in possession of Dr. S. G. Morton, of Philadelphia. He not only describes the "public squares" alluded to by Adair, in which the religious ceremonies of the Indians were performed, and their deliberative councils held, but also communicates the interesting and important fact that they sometimes appropriated to their purposes the ancient enclosures and other monuments found in the country, and concerning the origin of which they professed no knowledge. His account, apart from its bearings on the questions before us, has a general interest which justifies its insertion entire.

"Chunk Yards.—The 'Chunk Yards' of the Muscogulges or Creeks, are rectangular areas, generally occupying the centre of the town. The Public Square and Rotunda, or Great Winter Council House, stand at the two opposite corners of them. They are generally very extensive, especially in the large, old towns: some of them are from six to nine hundred feet in length, and of proportionate breadth. The area is exactly level, and sunk two, sometimes three feet below the banks or terraces surrounding them, which are occasionally two in number, one behind and above the other, and composed of the earth taken from the area at the time of its formation. These banks or terraces serve the purpose of seats for spectators. In the centre of this yard or area there is a low circular mound or eminence, in the middle of which stands erect the 'Chunk Pole,' which is a high obelisk or four-square pillar declining upwards to an obtuse point.* This is of wood, the heart or inward resinous part of a sound pine tree, and is very durable; it is generally from thirty to forty feet in height, and to the top is fastened some object which serves as a mark to shoot at, with arrows or the rifle, at certain appointed times. Near each corner of one end of the yard stands erect a less pole or pillar, about twelve feet high, called a 'slave post,' for the reason that to them are bound the captives condemned to be burnt. These posts are usually

* This pole, it may here be observed, corresponds in position with certain erect stones, found by Mr. Stephens and other travellers, occupying the centre of the areas enclosed by the temples of Central America and Yucatan, and which, as will be seen in due time, were undoubtedly *phallic* emblems.

decorated with the scalps of slain enemies, suspended by strings from the top. They are often crowned with the white dry skull of an enemy.

"It thus appears that this area is designed for a public place of exhibition, for shows, games, etc. Formerly, there is little doubt, most barbarous and tragical scenes were enacted within them, such as the torturing and burning of captives, who were here forced to run the gaunlet, bruised and beaten with sticks and burning chunks of wood. The Indians do not now practise these cruelties; but there are some old traders who have witnessed them in former times. I inquired of these traders for what reason these areas were called '*Chunk Yards;*' they were in general ignorant, yet, for the most part, concurred in a lame story that it originated in the circumstance of its having been a place of torture, and that the name was but an interpretation of the Indian term designating them.*

"I observed none of these yards in use in any of the Cherokee towns; and where I have mentioned them, in the Cherokee country, it must be understood that I saw only the remains or vestiges of them among the ruins of ancient towns, In the existing Cherokee towns which I visited, although there were ancient mounds and signs of the yard adjoining, yet the yard was either built upon or turned into a garden plat, or otherwise appropriated. Indeed, I am convinced that the Chunk Yards now or lately in use among the Creeks are of very ancient date, and not the work of the present Indians; although they are now kept in repair by them, being swept very clean every day, and the poles kept up and decorated in the manner I have described.

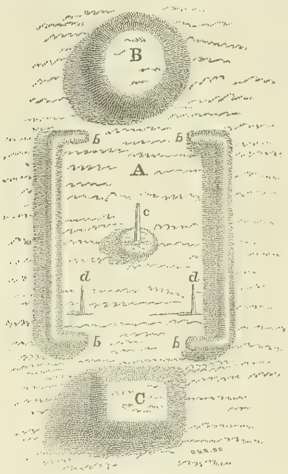

Fig. 37.

"The following plan, Fig. 37, will illustrate the form and character of these yards.

"A. The great area, surrounded by terraces or banks.

"B. A circular eminence, at one end of the yard, commonly nine or ten feet higher than the ground round about. Upon this mound stands the great *Rotunda*, *Hot House*, or *Winter Council House* of the present Creeks. It was probably designed and used by the ancients who constructed it, for the same purpose.

"C. A square terrace or eminence, about the same height with the circular one just described, occupying a position at the other end of the yard. Upon this stands the *Public Square*.

"The banks enclosing the yard are indicated by the letters *b*, *b*, *b*, *b*; *c* indicates the '*Chunk Pole*,' and *d*, *d*, the '*Slave Posts*.'

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* According to Adair, Du Pratz, and other writers, the Cherokees and probably the Creeks were much addicted to a singular game, played with a rod or pole and a circular stone, which was called *chungke*. Mr, Catlin describes this game as still existing under the name of "*Tchung-kee*," among the Minitarees

"Sometimes the square, instead of being open at the ends, as shown in the plan, is closed upon all sides by the banks. In the lately built or new Creek towns, they do not raise a mound for the foundation of their rotundas or public squares. The yard, however, is retained, and the public buildings occupy nearly the same position in respect to it. They also retain the central obelisk and the slave posts.

ARRANGEMENT OF THE PUBLIC BUILDINGS.

"The following engraving, Fig. 38, exhibits the most common plan or arrangement of the Chunk Yard, Public Square, and Rotunda, in the *modern* Creek towns.

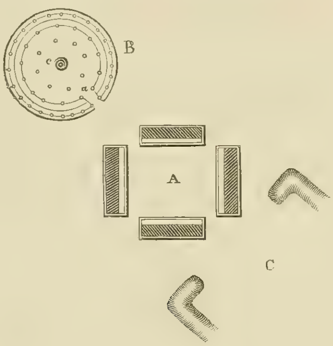

FIG. 38.

"A. The Public Square.

"B. The Rotunda: *a*, the entrance opening towards the square; the three circular lines show the rows of seats or rude sofas; the punctures show the posts or columns which support the building; *c*, the great central pillar, surrounded by the spiral fire which gives light to the edifice.*

"C. Part of the Chunk Yard.

"Within this Rotunda, they seem to keep the Eternal Fire, where it is guarded

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and other tribes on the Missouri. It also prevailed among some of the Ohio Indians. It has been suggested that the areas called *chunk* or *chunky yards* by Bartram, derived their names from the circumstance that they were, amongst other objects, devoted to games, among which, that of the *chungke* was prominent. This suggestion derives some support from Adair, who says, "They have, near their State House, a square piece of ground, well cleared; and fine sand is strewn over it when requisite to promote a swifter motion to what they throw along it."—(*American Indians*, p. 402.) It is therefore not improbable that these square areas were denominated *chungke* yards.

* It is to be regretted that our author has not given the dimensions of the "Rotunda." It would be interesting to know how it would compare, in that respect, with the small circles so common throughout the West.

by the priests. Within it the new fire is kindled on the occasion of the Feast of the First Fruits. No woman is allowed to step within the Rotunda, and it is death for any to enter None but a priest can bring the sacred fire forth. The *spiral fire* in the centre of the building is very curious: it seems to light up into a flame, of itself, at the appointed time; but how this is done I know not.

THE PUBLIC SQUARE.

"The Public Square of the Creeks consists of four buildings of equal size, placed one upon each side of a quadrangular court. The principal or Council House, is divided transversely into three equal apartments, separated from each other by a low clay wall. This building is also divided longitudinally into two nearly equal parts; the foremost or front is an open piazza, where are seats for the council. The middle apartment is for the king (*mico*), the great war chief, second head man, and other venerable and worthy chiefs and warriors. The two others are for the warriors and citizens generally. The back apartment of this house is quite close and dark, and without entrances, except three very low arched holes or doors for admitting the priests. Here are deposited all the most valuable public things, as the eagle's tail or national standard, the sacred calumet, the drums, and all the apparatus of the priests. None but the priests having the care of these articles are admitted; and it is said to be certain death for any other person to enter.*

"Fronting this is another building, called the 'Banqueting House;' and the edifices upon either hand are halls to accommodate the people on public occasions, as feasts, festivals, etc. The three buildings last mentioned are very much alike, and differ from the Council House only in not having the close back apartment.

"The clay-plastered walls of the Creek houses, particularly of the houses comprising the Public Square, are often covered with paintings. These are, I think, hieroglyphics or mystical writings, of the same use and purpose with those mentioned by historians to be found upon the obelisks, pyramids, and other monuments of the ancient Egyptians. They are much after the same style and taste; and though I never saw an instance of perspective or *chiaro-oscuro*, yet the outlines were bold, natural, and turned to convey some meaning, passion, or admonition, and they may be said to speak to those who can read them. The walls are plas-

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* This is probably the apartment designated by Adair as the *sanctum sanctorum*. Du Pratz (p. 351) states that the temples of the Natchez were divided into two apartments, in the larger of which the eternal fire was kept. "The inner apartment," he observes, "was very dark, receiving no light except what came in at the door. I could meet nothing here but two boards, on which were placed some things like small toys, which I had not light to peruse." These sacred inner rooms cannot fail to remind us of the dark chambers of Palenque and Copan, within which Mr. Stephens discovered the mystical tablets described in his volumes on Central America. Nor is it difficult to trace a correspondence between the pictured walls of these buildings, as described in the text, and the sculptured fronts and elaborately painted walls of the Central American temples.

tered very smooth with red clay; then the figures or symbols are drawn with white clay, paste, or chalk: if the walls are plastered with white clay, the figures are sketched in red, brown, or blueish paste.

"Almost all kinds of animals, sometimes plants, flowers, trees, etc., are depicted; also figures of men in various attitudes, some very ludicrous and even obscene. In some instances, the *membrum generationis virile* is represented; but I saw no instance of indelicacy in a female figure. Men are often pictured with the head and other members of different kinds of animals, as the wolf, buck, hare, horse, buffalo, snake, duck, turkey, tiger, cat, crocodile, etc., etc. All these animals, on the other hand, are depicted having the human head and other members, as also the head and members of other animals, so as to appear monstrous.

CREEK TOWNS AND DWELLINGS.

"The general position of the Chunk Yard and Public Buildings of the Creeks, in respect to the dwellings of the Indians themselves, is shown in the following engraved plan:

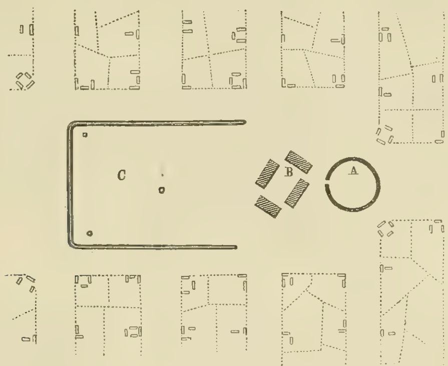

Fig. 39.

"A is the Rotunda; B, the Public Square; C, the grand area, or Chunk Yard. The habitations of the citizens are placed with considerable regularity in streets or ranges, as indicated in the plan."*

The inference might not unreasonably be drawn, from Bartram's language, that the rectangular areas, surrounded by embankments, as also the square and circular

* "The dwellings of the Upper Creeks consist of little squares, or rather of four oblong houses enclosing a square area, exactly on the plan of the Public Square. Every family, however, has not four of these houses: some have but three, others not more than two, and some but one, according to the circumstances of the individual or the number of his family. Those who possess four buildings have a particular use for

mounds above mentioned, were constructed by the Creeks. He, however, states explicitly, in his Travels, that the country in which these remains occur was occupied subsequently to the arrival of Europeans by the Cherokees, who were afterwards dispossessed by the Creeks; and that "it was probably, many ages preceding the Cherokee invasion, inhabited by a single nation or confederacy, governed by common laws, possessing like customs, and speaking the same language, but so ancient, that neither the Creeks nor the Cherokees, nor the nations they conquered, could render any account by whom or for what purposes these monuments were erected." He also inclines to the belief, that the uses to which these structures were appropriated, by the existing Indian tribes, were not widely different from those for which they were originally built. Upon this point he adds: "The mounds and large areas adjoining them seem to have been raised in part for ornament and recreation, and likewise to serve some other public purpose, since they are always so situated as to command the most extensive prospect over the country adjacent. The square terraces may have served as the foundations of fortresses; and perhaps the great pyramidal mounds answered the purpose of look-outs, or were high places for sacrifice."—(*Travels*, p. 518.)

From this account we gather the important fact, that in the centre of the Creek (as also of the Cherokee) towns was a "public square," surrounded by edifices devoted to public purposes; and that accompanying this square, and placed in a fixed position in respect to it, was an edifice, circular in form, which was more

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each: one serves for a cook-room or winter lodging-house, another as a summer lodging-house and hall for visitors, and another for a granary or store-house, etc.

"The accompanying cut (Fig. 40) illustrates the plan of the dwelling or villa of a Creek chief known

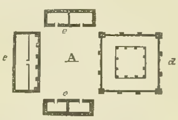

Fig. 40.

among the traders by the name of Bosten. A is the area enclosed by four buildings: the one upon the left, *e*, was his lodging-house, and was large and commodious; the building opposite was a large, square, open pavilion, covered by a cedar roof, which was supported by two rows of posts or pillars. Between each range of pillars was a platform, raised about two feet and ascended by two steps; this was covered with checkered mats of curious workmanship, woven of splints of canes variously colored. In the centre of the pavilion was a square platform, raised somewhat higher than the others, and also covered with mats. In this delightful, airy place, visitors were received and entertained. The remaining two buildings were used, the one as a cook-house, the other as a store-house.

"The Lower Creeks, or Seminoles, are not so regular in their buildings, public or private. The private houses of the Cherokees consist of one oblong log building, divided transversely into several apartments,

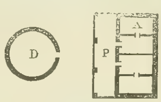

Fig. 41.

with a portico in front; a round house, D, stands a little distance off, and is used as a winter lodging-house."

especially dedicated to religious purposes, and within which was kept up the eternal fire. In some cases these structures, it seems, were elevated upon mounds.

Mr. Payne, in his MSS., thus describes the great Council House of the Cherokees, which corresponds with the "Rotunda" mentioned by Bartram. After remarking that it was near this that the dwellings of the *Uku* and head men of the tribe were erected, and that it was always situated in a town capable of accommodating a great number of people, he proceeds:

"Every part bore a mystical reference to the sanctity with which they regarded the number *seven.* Seven posts were set deep in the ground, equi-distant from each other, so as to form seven equal sides; though generally the roof, when it touched the ground, as it sometimes did, was entirely circular. Upon the seven posts seven very long beams were so placed, as to rest one end on the ground, or periphery *raised two or three feet with earth*, while the other end stretched high in air, and all soon met at a point directly over the centre of the floor. Other pieces of timber were fastened transversely to these, answering for ribs: at first they were thatched with grass, and over it a layer of clay, surmounted with another layer of grass, so as to make it water-proof. The external appearance of the entire building very much resembled an immense charcoal-pit. There was an opening in the roof for the escape of the smoke. The fire was in the centre. Anciently, they say, this was the sacred fire handed down from above.

"The Council House door was always on the eastern side, directly toward the rising sun. Before it was a portico. The seven posts which supported the house were so set, that one stood directly opposite the entrance, on the west side of the structure. It was painted white, and had pins and shelves attached to it, on which were hung or laid all the holy things connected with their worship. * * The space which was regarded as most sacred, was that immediately back of the seat of the *Uku*, near the white post already mentioned. Among the sacred things kept here were the sacred arks, and smaller arks of clay for conveying the holy fire. * * * Adjacent to the Council House, there was a large public square, the sides formed by four one-story structures. The entrances at each corner were wide and open. These structures were open in front like piazzas, and each one was partitioned off into several divisions, etc."

The embankment designating the outlines of the structure here described, may be regarded as throwing direct light upon the origin of the small circles so abundant in the valley of the Ohio.

In the account of La Salle's last expedition to the mouth of the Mississippi, published by the Chevalier Tonti, we have a brief notice of the *Taencas* or Tenzas, from which the following interesting passages, relating to the questions before us, are extracted.

"As the first village of the *Taenca* stands on the other side of a lake which is eight leagues in circumference, and half a league over, we were forced to take a canoe to cross it. As soon as we landed, I was surprised to see the grandeur of the village, and the order of the cottages; they are placed in divers rows, and in a straight line, round about a large space, being all made of earth and covered over with mats of cane. We presently took notice of two, fairer than the rest, one of

which was the prince's palace, and the other the temple. Each of them was forty feet square, and the walls ten feet high and two feet thick, the roof in the form of a cupola, and covered with a mat of divers colors. * * * As to their religion, the prince told me that they worship the sun; that they had their temples, their altars, and their priests. That in their temple there was a fire which burned perpetually, as the proper emblem of the sun. That at the decrease of the moon, they carried a great dish of their greatest dainties to the door of the temple, as an oblatory sacrifice; which the priests offered to their God, and then carried it home and feasted themselves therewith. * * * The next day I had the curiosity to see their temple, and the old gentleman led me thither. The structure of it was exactly the same with that of the prince's house. *As to the outside, it is encompassed with a great high wall, the space betwixt that and the temple forming a kind of court where people may walk.* On the top of the wall were several pikes to be seen, upon which were stuck the heads of their own most notorious criminals, or of their enemies. On the top of the frontispiece, there is a great knob raised, all covered round with hair, and above that a heap of scalps, in the form of a trophy. * * The inside of the temple is only a *Nave*, painted on all sides, at top with all sorts of figures; in the midst of it is a hearth raised in the form of an altar, upon which there is burning continually three great billets of wood, standing up on end; and two priests, dressed in white vestments, are ever looking after it to make up the fire and supply it. It is round this the people come to say their prayers with strange kind of hummings. The prayers are three times a day: at sunrise, at noon, and at sunset. They made me take notice of a sort of closet cut out of the wall, the inside of which was very fine. I could only see the roof of it, on the top of which there hung a couple of spread eagles, which looked towards the sun.* I wanted to go in; but they told me it was the tabernacle of their God, and that it was permitted to none but their high priest to go in. And I was told it was the repository of their wealth and treasures, as jewels, gold and silver, precious stones, and some goods that came out from Europe, which they had from their neighbors.—(*La Salle*, *Trans. N. Y. Hist. Soc.*, Vol. II., pp. 269, 272.)

THE TEMPLES OF MEXICO, CENTRAL AMERICA, AND PERU.

The pyramidal temples of the Aztecs, which perhaps better deserve the name of altars, or the scriptural name of "high places," were always surrounded by large enclosures, most usually of a square form. The great temple of Mexico, which is described by all the early authors as nearly identical in form and structure with all the principal temples of Anahuac, consisted first of an immense square area, "surrounded by a wall of stone and lime, eight feet thick, with battlements, ornamented with many stone figures in the form of serpents." The extent of this enclosure, which occupied the centre of the ancient city, may be inferred from the

* Adair speaks of "cherubimical figures in the Synhedria" of the Muscogulges or Creeks.—(p. 30.)

assertion of Cortez, that it might contain a town of five hundred houses. It was paved with polished stones, so smooth, says Bernal Diaz, that "the horses of the Spaniards could not move over them without slipping." The four walls of this enclosure corresponded with the cardinal points, and gateways opened midway upon each side, from which, according to Gomera, led off broad and elevated avenues or roads.—(*Purchas*, Vol. III., p. 1133.) In the centre of this grand area rose the great temple, an immense pyramidal structure of five stages, faced with stone, three hundred feet square at the base, and one hundred and twenty feet in height, truncated, with a level summit, upon which were situated two towers, the shrines of the divinities to which it was consecrated. It was here the sacrifices were performed and the eternal fire maintained. One of these shrines was dedicated to Tezcatlipoca, the other to Huitzlipochtli; which divinities sustained the same relation to each other, in the Mexican mythology, as Brahma and Siva in that of the Hindus. Both are the same god, under different aspects, and with the God of the Rain, Tlaloc, constitute a Triad, almost identical with that which runs through all the mythologies of the East.

Besides this great pyramid, according to Clavigero, there are forty other similar structures, of smaller size, consecrated to separate divinities; one was called *Tezcacalli*, "House of the Shining Mirrors," which was covered with brilliant materials, and sacred to *Tezcatlipoca*, the God of Light, the Soul of the World, the Vivifier, the Spiritual Sun; another to *Tlaloc*, the God of Water, the Fertilizer; another to *Quetzalcoatl*, said to have been the God of the Air, whose shrine was distinguished by being circular, "even," says Gomera, "as the winds go round about the heavens: for that consideration made they his temple round."

Besides these, there were the dwellings of the priests (amounting, according to Zarate, to 5,000) and of the attendants in the temples, and seminaries for the instruction of youth; and, if we are to credit some accounts, houses of reception for strangers who came to visit the temple and see the grandeur of the court; ponds and fountains, groves and gardens, in which flowers and "sweet smelling herbs" were cultivated for use in certain sacred rites, and for the decoration of the altars. "And all this," says Solis, "without retracting so much from that vast square but that eight or ten thousand persons had sufficient room to dance in, upon their solemn festivals." The area of this temple was consecrated ground; and it is related of Montezuma, that he only ventured to introduce Cortez within its sacred limits, after having consulted with and received the permission of the priests, and then only on the condition, in the words of Solis, that the conquerors "should behave themselves with respect." The Spaniards having exhibited, in the estimation of Montezuma, a want of due reverence and ceremony, he hastily withdrew them from the temple, while he himself remained to ask the pardon of his Gods for having permitted the impious intrusion.

There is a general concurrence in the accounts of this great temple given by the early authorities, among whom are Cortez, Diaz, and others, who witnessed what they described. They all unite in presenting it as a type of the multitude of similar structures which existed in Anahuac. Their glowing descriptions, making due allowance for the circumstances under which they wrote, are sustained by the

imposing ruins of Cholula, Papantla, Mitla, Xoxachalco, Misantla, Quemada, and the thousand other monuments which are yet unrecorded by the antiquary, and which invest every sierra and valley of Mexico with an interest hardly less absorbing than that which lingers around the banks of the Nile.

From the number of these religious structures, we gather some idea of the predominance of Mexican superstitions. Solis speaks of eight temples in the city of Mexico, of nearly equal grandeur with that above described, and estimates those of smaller size to amount to two thousand in number, "dedicated to as many idols of different names, forms, and attributes." Torquemada estimates the number of temples in the Mexican empire at *forty thousand*, and Clavigero places the number far higher. "The architecture," he adds, "of the great temples was for the most part the same with that of the great temple of Mexico; but there were many likewise of a different structure, composed of a single body in the form of a pyramid, with a staircase, etc." Gomera says, "they were almost all of the same form; so that what we shall say of the principal temple, will suffice to explain all the others." Cortez, in a letter to Charles V., dated October 30, 1520, states that he counted four hundred of these pyramidal temples at Cholula.

From all sources we gather that the principal temples, or rather sacred places of Mexico, consisted of large square areas, surrounded by walls, with passages midway at their sides, from which sometimes led off avenues or roads, and that within these enclosures were pyramidal structures of various sizes, dedicated to different divinities, as also the residences of the priests, with groves, walks, etc.

Proceeding to Central America, we still find, so far as we are informed concerning the remains of these countries, the sacred enclosure and the pyramidal temple. The enclosure surrounding the sacred edifices of Tuloom, already described in another connection (page 98), was most probably the consecrated ground of the ancient inhabitants. Its rectangular form and the position of its gateways go far to connect it with the corresponding structures of Mexico and the United States. Grijalva, the first discoverer of Yucatan, alluding perhaps to these very structures of Tuloom, "saw several places of worship and temples, wide at the bottom and hollow at the top, stately stone buildings, at the foot of which was an enclosure of lime and stone." Del Rio assures us that the principal structures, the temples, of Palenque, were placed in "the centre of a rectangular area, three hundred yards in breadth, and four hundred and fifty in length." Assuming the word "yard" to be a translation of the Spanish *vara*, which is about thirty-three inches in length, we have the dimensions of this area, 825 by 1240 feet. Herrara relates, concerning the building of the town of Mayapan, by the ancient inhabitants of Yucatan:

"They pitched upon a spot, eight leagues from the place where Merida now stands, and fifteen from the sea, where they made an enclosure of about half a quarter of a league [on each side?], being a wall of dry stone with only two gates. They built temples, calling the greatest of them *Cuculcan*, and near to the enclosure the houses of the prime men. * * It was afterwards ordered that, since the *enclosure was only for the temples*, the houses of the people should be built round about."—(*Herrara*, Vol. IV., p. 162.)

The accounts which we possess of the ancient religious structures of Peru, although glowing with admiration of their splendor and riches, are yet extremely vague as respects their plan of construction. Enough, however, is easily gathered to assure us that they consisted of large consecrated courts or areas, like those of Mexico, in which the temples proper were situated, together with fountains, gardens, and the residences of the priests.

The great Temple of the Sun at Cuzco, in the description of which the early Spaniards have expended every superlative of their language, consisted of a principal building and several chapels and inferior edifices, covering a large extent of ground, in the heart of the city, and completely encompassed by a circular wall, which, with the edifices, was constructed of stone. Aqueducts opened within this sacred enclosure; and within it were gardens, and walks among shrubs and flowers of gold and silver, made in imitation of the productions of nature. It was attended by four thousand priests. "The ground," says La Vega, "for two hundred paces around the temple was considered holy, and no one was allowed to pass within this boundary but with naked feet." Nor even under these restrictions were any permitted to enter, except of the blood of the Incas, in whom were centred the priestly and civil functions of the government.

Besides the great Temple of the Sun, there was a large number of inferior temples in Cuzco, estimated by Herrara at three hundred. Numerous other temples are scattered over the empire, all of which seem to have corresponded very nearly in structure with that already described. The most celebrated temple in Peru, next to that of Cuzco, was situated on an island in Lake Titicaca, where it was believed Manco Capac first made his appearance on earth. The whole surface of the island was considered sacred. The Temple of Pachacamac is described as being enclosed by walls, and to have "more resembled a fortress than a temple." According to Roman, "the temples of Peru were built upon high grounds or the tops of hills, and were surrounded by four circular embankments of earth, one within the other. The temple stood in the centre of the enclosed area, and was quadrangular in form."

A structure, corresponding very nearly with this description, is noticed by Humboldt, who denominates it, in accordance with local traditions, *Ingapilca*, "House of the Incas," and supposes it to have been a sort of fortified lodging-place of the Incas, in their journeys from one part of the empire to the other. It is situated at Cannar, and occupies the summit of a hill. The "citadel" is a very regular oval, the greatest axis of which is 125 feet, and consists of a wall, built of large blocks of stone, rising to the height of sixteen feet. Within this oval is a square edifice, containing but two rooms, which resembles the ordinary stone dwellings of the present day. Surrounding these is a much larger circular enclosure, which, from the description and plate, we infer is not far from five hundred feet in diameter. This series of works possesses few military features, and it seems most likely that it was a temple of the sun. This opinion is confirmed by the fact that, at the base of the hill of Cannar was formerly a famous shrine of the Sun, consisting of the universal symbol of that luminary formed by nature upon the face of a great rock. Humboldt himself admits an apparent dependence between this shrine and

the structures above described.—(*Humboldt's Res.*, Vol., pp. 242, 248 ; fol. plates, No. 17.) Ulloa describes an ancient Peruvian temple situated on a hill near the town of Cayambe, perfectly circular in form, and open at the top. It was built of unburnt bricks, cemented together with clay.—(*Ulloa*, Vol. I., p. 486.)

TEMPLES OF POLYNESIAN ISLANDERS, HINDUS, ETC.

Enclosures ruder in construction, yet nevertheless analogous in form and identical in purpose with those here described, were found among the Polynesian Islanders. The area of their temples was frequently a square or parallelogram, protected by stone walls, within which were pyramidal structures, sometimes of great size. One of these, within the great enclosure of *Atehuru*, was two hundred and seventy feet long, by ninety-four feet broad, and fifty feet high ; flat on the summit, which was reached by a flight of steps, much after the manner of the Mexican Teocalli. Within the sacred area, and at the base of these pyramidal structures, the idols were placed and their altars erected. Here also were the dwellings of the priests and of the keepers of the idols. The trees and other objects within the walls were sacred.—(*Ellis's Polynesian Researches*, Vol. I., p. 340.) In some instances, instead of an unbroken wall, the sacred area was indicated by a series of pyramidal heaps of stones, placed at intervals, so as to constitute the leading points of a square, within which was placed the temple proper. The ruins of a temple of this kind, called *Kaili*, still exist in the island of Hawaii.—(*U. S. Exploring Exped.*, Vol. IV., p. 100.)

When we extend our inquiries to the eastern shores of the old continent, we find in India the almost exact counterparts of the religious structures of Central America : analogies furnishing the strongest support of the hypothesis which places the origin of American semi-civilization in southern Asia. A close and critical comparison of these monuments, in connection with the systems of religion to which they were respectively dedicated, and the principles which governed their erection, may lead to most interesting and important results.

In another connection, some of the more obvious analogies will be pointed out ; with no view, however, of establishing dependencies, but for the purpose of illustration and elucidation. It is sufficient for our present objects to remark, that the temples of India and of the islands of the Indian seas, both of modern and ancient date, are constructed and enclosed in like manner with those already described. The consecrated area is sometimes of vast extent, equalling if not exceeding in this respect the largest of those which existed in Mexico. These enclosures are square, and usually have their entrances corresponding to the cardinal points. "The general style of these buildings," says Bishop Heber, "is a large square court, sometimes merely surrounded by a low brick wall, with balustrades, indented at the top, with two or sometimes four towers at the angles. In the centre of the principal front is, for the most part, an entrance, often very handsome. In the middle of the quadrangle, or in the middle of one of its sides opposite the main entrance, is a pyramid, which is the temple of the principal deity. The structure

is sometimes octagonal, but mostly square."—(*Heber's Travels*, Vol. I., Chap. 3.) "Sometimes a number of temples are built within this sacred area. One at Chanchra, in Jesson, has twenty-one temples, and one thousand acres of ground." —(*Ward*, Vol. III., p. 230.) The Pagoda of Seringham is one of the most magnificent in India. It stands on an island in the river *Careri*, in the dominions of the Rajah of Tanjore. Seven square enclosures, formed by walls twenty-five feet high, four feet thick, and three hundred and fifty feet distant from each other, enclose a court in the centre, in which are sacred pyramidal structures, the abodes of the gods of the Hindu pantheon, and among them the sanctuary of the Supreme Vishnu. These various deities are believed really to animate their respective pyramids or shrines. Four large gates, one in the middle of each side, each surmounted by a tower, are the entrances to the several courts. The outer wall is four miles in circumference. The number of the enclosures has a symbolical signification, and refers to the several regions into which the Universe, the abode of the gods, was supposed to be divided, according to the theory of the age in which the structure was built.—(*Dudley's Naology*, p. 104; *Colman's Mythology of the Hindus*, p. 157; *Maurice's Indian Antiquities*, Vol. III., pp. 13, 50.) The great temple of Jaggenath, at Orissa, the general resort of all Hindu sects, is regarded as possessing such exceeding sanctity, that the earth for twenty miles round is considered holy. The most sacred spot is an enclosed area about six hundred and fifty feet square, which contains the temples of the idol and his sister, surrounded by fifty lesser temples, all of pyramidal form.—(*Colman's Myth. of the Hindus*, p. 52.)

In the Island of Java are the remains of many ancient temples, of similar character and construction. A large number of these, designated as the ruins of Prambanai, exist in the district of Pajang. One of the most perfect of the groups occurring here is termed by the natives "the Thousand Temples." The group occupies a rectangular area six hundred feet long and five hundred and fifty feet broad, and consists of four rows of small pyramidal structures, enclosing a court, in which is placed a large pyramidal edifice. The whole is surrounded by a wall, having entrances midway on each side. Some of these groups are disposed in squares of greater or less dimensions, but all have a common character.—(*Crawford's Indian Archipelago*, Vol. II., p. 196; *Asiatic Researches, Calcutta*, Vol. XIII.) There are also single temples of like form, occasionally of great size, and generally surrounded by a series of enclosures.

The religious edifices and pyramidal shrines of the Japanese are described by Kæmpfer as "sweetly seated" in the midst of large square enclosures, approached by spacious avenues, and embracing within their walls springs, groves, and pleasant walks. "The empire," observes our authority, "is full of these temples, and their priests are without number. Only in and about Miaco, they count nearly 4,000 temples and 37,000 priests."—(*Kæmpfer's Japan*, Vol. II., p. 416.)

These examples might be greatly multiplied, so as to extend the chain of analogies quite around the globe. Passing, however, over the intermediate space, we come at once to the British Islands.

PRIMITIVE TEMPLES OF THE BRITISH ISLANDS.

The British Islands, and the portion of the continent adjacent to them, abound in ancient monuments, closely allied to those under consideration. They have been very accurately investigated and described by Camden, Borlase, Douglas, Hoare, Cunnington, Higgins, Deane, and numerous others; and the world is familiar with their character. The researches of these investigators have directed upon them all the lights of erudition. Availing ourselves at once of the results of their labors, we apply them to the elucidation of the mysterious monuments of our own country.

The analogies which exist between one class of ancient British remains and a corresponding class of American structures, have already been briefly pointed out. There is, however, another large division, more numerous and more interesting than these, of widely different form and manifestly different design. These consist, for the most part, of circular structures, of greater or less dimensions, composed of earth or of upright stones placed at short distances apart. These circles are sometimes of great size, embracing many acres of ground; but most are of moderate dimensions, corresponding in this as generally in other respects with those of this country. They are regarded by all well informed British antiquaries as religious in their origin, and connected with the ancient Druidical system. This conclusion is not entirely speculative, but rests in a great degree upon traditional and historical facts. Borlase observes, "The grandeur of design, the distance of the materials, the tediousness with which all such massive works are erected, all show that they were the fruits of peace and religion." "That they were erected," says Hoare, "for the double purpose of civil and religious assemblies, may be admitted without controversy. They were public edifices, constructed according to the rude fashion of the times, and at a period when the Deity was worshipped in the most simple and primitive manner, under the open canopy of heaven."—(*Ancient Wiltshire*, Vol. II., p. 122.) Cæsar, writing of the Druids, is understood to allude to their sacred structures in the following terms: "*Druides, certo anni tempore, considunt in* LOCO CONSECRATO. *Hùc omnes undique qui controversias habent conveniunt, eorumque judiciis decretisque parent.*"—(*Cæsar, de Bello Gallico*, Lib. VI.) "Once a year the Druids assemble at a *consecrated place.* Hither such as have suits depending flock from all parts, and submit implicitly to their decrees." It need not be added, that the Druids were priests and judges, the expounders of religion and the administrators of justice; they were entrusted with the education of youth, and taught the motions of the stars, the magnitude of the earth, the nature of things, and the dignity and power of the gods. They officiated at sacrifices and divinations; they decided controversies, punished the guilty, and rewarded the virtuous. Their power was superior to that of the nobles, over whom they wielded the terrors of excommunication from a participation in the imperative rites of their religion. They centred in themselves the occult learning of the day,

which seems to have been closely allied to that of Phœnicia, if not, indeed, mainly derived from the East.

"The sacred places of the Druids were enclosed sometimes with a fence of palisades, and sometimes with a mound of earth, or with stones, to keep off the profane, and prevent all irreverent intrusion upon their mysteries.* Tacitus relates that the early Germans considered their groves and woods as sacred: these spots were consecrated to pious uses, and the holy recess took the name of the divinity who filled the place, and whose sanctuary was never permitted to be seen but with reverence and awe. Agreeable to this was the early practice of the Britains, who, according to the same authority, used similar customs with the Germans."—(*Germania*, C. ix. and C. xl.) In the form of their temples, the Druids, for the most part, adopted the circle; and the generally received opinion is, that all *circular monuments* were originally intended for devotional purposes.

There are some earth-works in the British Islands, which were clearly not defensive, but yet are rectangular. To these, authors have hesitated in ascribing a date. One of the most singular of these, which corresponds very nearly with that discovered near Tarlton, Pickaway county, Ohio (*Ancient Monuments of the Mississippi Valley*, Plate XXXVI., No. 1), occurs upon Banwell Hill, county of Wilts, England. The accompanying engraving (Fig. 42) is reduced from the plan given

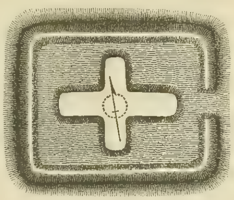

Fig. 42.

by Sir R. C. Hoare, who notices it briefly as follows: "Before quitting this interesting eminence, I must not omit to take notice of a very singular little earth-work, situated towards the village of Banwell. Its form proclaims it to be Roman; but I cannot conceive to what use it was destined. The embankment enclosing the cross is two hundred and thirty yards in extent, and encloses nearly three-quarters of an acre."—(*Ancient Wiltshire*, Vol. II.; *Roman Era*, p. 43.) There is certainly a most striking coincidence; yet it is one which it would be unsafe to regard as any other than accidental.

It may not be wholly inappropriate to mention that some of the most ancient temples of India are built in the form of a cross; such is the shape of the great

* Salopia Antiqua, p. 10. Hermoldus, in his Chronicon de Rebus Salivæ, says that the Sclavonians prevented all access to their groves and fountains, which they considered would become desecrated by the entrance of Christians. They had their sacred oaks, which they surrounded by a fence of wicker-work. The *tabooed* palms and other trees of the Marquesas and South Sea Islanders are protected from profane contact in a like manner.

temple at Benares, and that at Mathura. At the intersection of the four arms rises a lofty dome. Such also is the shape of the subterranean temple of New Grange, in Ireland.—(*Tavernier* Vol. III., pp. 30, 47 ; *Faber's Pag. Idol.*, Vol. III., p. 287 ; *Higgins's Celtic Druids*, p. 40.)

The circular form is certainly best adapted for the reception of the devotees desiring to see and hear, or to participate in parts of the sacrificial rites practised within them. But it is claimed, and upon an array of evidence which will admit of no dispute, that the form of the primitive temple was, with great uniformity, that of the symbol of the religion to which it was consecrated, or of the god to whose worship it was dedicated.

The circle is the uniform symbol of the sun, alike among the most savage as the most enlightened nations; and the fact that most of the ancient religious structures of the British islands are of that form, would seem to imply that the god of Celtic adoration was symbolized as the Sun, and that the ancient Celtic religion was a modification of what is usually termed sun or fire worship. This implication is sustained by abundant evidence, into which it is impossible, as it would be out of place, to enter here. We have every reason for believing that the objects of the Druidical worship were identical with those of the followers of Baal, (the Sun).* Like them, the Druids were addicted to the study of the heavens, and in the same way they offered up sacrifices to Baal, Bel, Belus, Belinus, Moloch, Apollo, or the Sun. The connection of Druidism with the name of Baal, is well known in the lines of Ausonius—himself a Druid—who writes:

"Tu Baiocassis, stirpe Druidum satus,
Si fama non fallit fidem,
Belini sacratum ducis e templo genus."

Cæsar says the Gauls worshipped Apollo: the Gauls were followers of the Druidic rites according to the same authority.

SYMBOLISM OF TEMPLES.

The rationale of symbolism, as connected with temples, next claims our attention. Not only was the doctrine of occasional presence of universal acceptance amongst the followers of every early religious system, but they believed that the gods made temples and sacred structures their places of constant abode. Their presence, in some instances, was supposed actually to animate their shrines, and

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* Salopia Antiqua, p. 7. The evidence upon this point, as remarked in the text, is alike abundant and conclusive. The Phœnicians, who undoubtedly penetrated into the British islands at a very early day, introduced many of their own habits and superstitions. They were the carriers of customs and opinions, as of wares, and dispensed the seeds both of African and Asiatic idolatry in Europe. This conclusion is sustained not only by the striking resemblance between many of the religious rites of the ancient Celts and those of Assyria and Egypt, but by etymological evidences of a most positive character.—(*Thackeray's Ancient Britain*, Vol. I., pp. 10, 14; also, *Introduction to Ancient Wiltshire*, and *Higgins's Celtic Druids*, ubi supra.)

to consecrate the earth around them. The Jews were assured that Jehovah dwelt between the emblematic cherubim. In the hope of rendering his homage in the actual presence of his God, the Mohammedan pilgrim makes his weary journey to Mecca, and the Hindu devotee seeks, from the remotest provinces, the shrine of Jaggenath. The same idea of a living presence is manifested in the superstition of the savage, who regards every remarkable tree, rock, cave, spring, or stream, as the evidence or actual impersonation of a divinity, and renders his homage in accordance with his belief.

The presence of the gods was formerly supposed to be favorable, and powerfully conducive, if not indispensably necessary, to the prosperity of cities and nations; and as such was ever desired and ever a cause of joy and exultation. The poet Horace addresses the goddess Venus in terms significant of the benefits resulting from her presence:

> "O Goddess in blest Cyprus dwelling,
> And Memphis wanting of Sithonian snow!"

So, too, Homer alludes to the celestial mountain of Greece:

> "Olympus famed, the safe abode of gods,
> By winds is never vexed, nor drenched with rain.
> Snow falls not; but the cloudless arch serene
> Widely expands; with brightness ever clear."

Influenced by opinions such as these, we can readily understand how the temple might take the symbolical form of the god to whose worship it was dedicated; thereby being made more acceptable as his abode, at the same time that its form proclaimed his presence. Sallust, in his treatise on the Gods and the World, illustrates this ancient doctrine in the following words: "As the providence of the gods is everywhere extended, a certain habitude or fitness is all that is necessary in order to receive their beneficent communications. But all habitude is produced through imitation and similitude; and hence temples imitate the heavens, but altars the earth; statues resemble life, and on this account are similar to animals, etc."*

The earth, remarks an ingenious writer, being regarded as God by a large portion of the heathen world, any structure bearing that form might justly be considered as a symbol of the Deity, indicative of his power and his presence. The

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* The Pantheon at Rome was dedicated to all the gods; who, instead of rude shrines consecrated to each, as in the great temple of Mexico, had their statues placed within the vast rotunda. The great concave dome, we are expressly told by Pliny, was designed to represent the vault of Heaven; "quod forma ejus convexa fastigiatam *cœli similitudinem* ostenderet." Yet it seems to have been eminently a temple of the solar Apollo, whose colossal image was placed immediately in front of the entrance, the first and most imposing object which met the eye of the spectator.—(*See Faber, Pagan Idolatry*, Vol. III., p. 284; *Maurice, Ind. Antq.* Vol. III., p. 185.) Mr. Dudley, who claims that the circle and the square were the symbols of the reciprocal powers of nature, assumes that the circular Pantheon, with its quadrangular portico, was intended to signify the union of the two principles or powers.—(*Naology*, p. 390.)

import of the symbol caused the conviction and assurance that all sacred structures ought, of necessity, to be constructed in its form.—(*Dudley on Symbolism*, p. 43.)

This conviction seems to have prevailed among the Hebrews: the "Ark of the Covenant," in which were deposited the tables of the law, was essentially symbolical in its form. The form of the Tabernacle in the wilderness, and of the great temple on Mount Zion, we may infer, was regarded as a matter of importance, from the specific directions given for their construction. And the primitive Christians, we are assured, were in a like manner influenced in the form of their sacred edifices.*

Vesta, in the later mythologies, was the igneous element personified; her globular temple on the banks of the Tiber represented, we are told, the Orb of the Earth, cherished and made prolific by the central fire.—(*Maurice, Ind. Antq.*, Vol. III., p. 130.) The reason for the obicular or oval form of her temple was recognised in Ovid's day. He writes:

"What now is roofed with brass, was then of straw,
And the slight osier formed the wattled wall.
This spot, that now the fane of Vesta bears,
The palace was of Numa, king unshorn.
'Tis said the form is now, as erst of old;
And the true reason may be well approved:
Vesta and Earth are one. A ceaseless fire
Burns in them both, and both alike pervades.
The earth, a globe supported on no prop,
Hangs, heavy weight, in all-subjected air."

Ovid, Fast., Lib. VI., 261.

Plutarch alludes, in similar terms, to the symbolical significance of the form of this temple. "Numa built a temple of orbicular form, for the preservation of the sacred fire; intending by the *fashion* of the edifice to shadow out, not so much the earth, or Vesta considered in that character, as the *whole universe;* in the centre of which the Pythagoreans placed fire, and which they called Vesta and Unity."†

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* "In respect to the form and fashion of their churches, it was for the most part oblong, to keep (say some, vide *Constit. Apost.*, L. ii., C. 57) the better correspondence with the fashion of a ship; the common notion or metaphor by which the church was wont to be represented."—(*Cave's Prim. Christianity*, p. 65.)

† *Plutarch, de Iside et Osiride.* M. Ramée has well expressed this idea in his "*Histoire Générale de l'Architecture,*" from which we translate the following passage:

"Among all the people of antiquity, intimately connected with the idea of God, was that of the Earth as his habitation, and Heaven as his eternal home. The universe, and especially the visible heavens, was for this reason considered as a true Temple of the Divinity, built by Himself, and was held as the primitive Temple, to be taken as a model, as the type of all temples to be raised by the hand of man. It was, therefore, considered unworthy of God and contrary to the idea held of Him, to erect sanctuaries to the Supreme Being on the same plan as the houses which man built for himself as a shelter and protection against the changes of the seasons. A habitation for God, it was thought, should resemble the Universe; and for that reason it would bear a divine character, and the Divinity would therein be, as it were, at home. Hence the construction of temples was regarded, in all antiquity, as a religious or hieratic art, the inventors and masters of which, at first, were the gods themselves."

The notions already alluded to as influencing the *forms* of temples, controlled also the choice of their position, the nature of their materials, and, when they were advanced from their primitive rudeness, the character of their ornaments. The crescent crowns the minaret of the Mohammedan; the symbolic trident of Siva, the dome consecrated to his worship; and the cross, in like manner, designates the church of the Christian. The significance of the trident is not less obvious to the Hindu, than that of the crescent to the Turk, or the symbol of his religion to the Christian; yet to the stranger to each, they would possess no higher value than might attach to them in their character of ornaments.

Were it necessary to our purpose, the illustrations of the various points here indicated might be greatly extended. Enough has, however, been said to place in a plausible light the fact (which probably no one would be disposed to deny), that the form of the primitive temple was, to an eminent degree, symbolical. In the words of Deane, "The figure of the temple, in almost every religion with which we are acquainted, is the hierogram of its God. The hierogram of the sun was always a circle: the temples of the sun were *circular*. The Arkites adored the personified ark of Noah: their temples were built in the form of a *ship*. The Ophites adored a serpent deity: their temples assumed the form of a *serpent*. And to come home to our own times and feelings, the Christian retains a remnant of the same idea when he builds his temples in the form of a *cross;* the cross being at once the symbol of his creed, and the hierogram of his God."—("*Observations on Dracontia, by Rev. J. B. Deane, British Archæologia*, Vol. XXV., p. 191.)

It is the fact that the religious conceptions, the philosophy and physical speculations of the ancients, exerted a controlling influence upon the construction of their sacred edifices, that invests those monuments with interest, not only as works of art, but as illustrations of man's primitive beliefs,—his notions of cosmogony, and his philosophy of the earth and heavens. "On every review," observes an eminent author, "and from every region, accumulated proofs arise, how much more extensively than is generally supposed the designs of the ancients in architecture were affected by their speculations in astronomy, and by their mythological reveries."—(*Maurice, Ind. Antiq.*, Vol. III., p. 199.)

Having already taken this brief survey of the character of the various primitive religious structures of various parts of the world, and having indicated the principles upon which those with the origin of which we are acquainted, sustaining the closest analogy to those of our own country, were constructed, we return with new aids to the investigation of the latter.

As has already been several times observed, the aboriginal temples, or rather sacred enclosures, of the Mississippi valley are nearly all of regular figures, usually circular or elliptical, sometimes square or rectangular; exhibiting in this respect, as also in their manner of combination, a uniformity which could only result from a fixed and well recognised design. Nothing can be more obvious than that they were built in accordance with a general plan, founded upon certain definite principles; and it is impossible to resist the conviction that their various forms and combinations possessed some degree of significance, and sustained some relation to the worship to which they were dedicated. We arrive at these conclu-

sions from a simple contemplation of the monuments themselves, unaided by the suggestions of analogy, or the evidence furnished by the concurrent practice of all early nations.*

When, however, we find these conclusions sustained by analogies of the most striking character, and discover that the mythological and philosophical notions of primitive nations exhibited themselves in a symbolical system which extended even to the form, position, and ornaments of their temples, then our conclusions become invested with a double value, and we proceed with some degree of confidence to inquire how far we are justified in supposing that the ancient structures of the Mississippi valley indicate the character of the worship to which they were dedicated. We have, it is true, neither the light of tradition nor of history to guide our inquiries; the very name of the mysterious people by whom these works were erected is lost to both, and a night darker than that which was prophesied should shroud the devoted "cities of the plain" rests upon them. Under these disadvantages, every attempt to clear up the darkness may fail; if, however, but partially successful, if but a single ray of light be directed upon the subject of our inquiries, the attempt will not be in vain, nor stand in need of an apology.

By far the larger proportion of the sacred structures of our country are circular in form; so also were the temples of the ancient Celts, for the received reason that they were dedicated to the worship of the Sun, whose most obvious and almost universal symbol is the circle. Assuming, upon the basis of this and other analogies, that their circular form is allusive to the former existence, among the people by whom they were built, of a similar system or form of worship, what further support do we find for the assumption, in the known religious notions of the various American tribes and nations? If, in answer to this question, it should be found that *Sun Worship*, if not of universal prevalence, greatly predominated throughout the continent, the assumption already so well sustained by analogy rises into the dignity of a well supported hypothesis.

It has already been remarked, in another connection, that the worship of the Sun was not less general in America than it was at one period among the primitive nations of the Old World. It existed among the savage hunter-tribes and among the semi-civilized nations of the South; where it assumed its most complicated and imposing form, and approximated closely to that which it sustained at an early period among the Asiatic nations,—the Egyptians, Assyrians, Hindoos, Scythians, and their offshoots in Europe. It is well known that it predominated in Peru, and was intimately connected with the civil institutions of that empire. The race of the Incas claimed their descent from the sun; to that luminary they erected their most gorgeous temples; and the eternal fire, everywhere emblematic of its influences, was watchfully maintained by the virgins consecrated to its service. The royal Inca himself officiated as priest of the sun, on every return of its annual festival. The Peruvians also paid adoration to the moon, as the "wife of the sun,"—a clear recognition of the doctrine of the reciprocal principles. In

* "Nothing," says M. Leibnitz, "happens without a *reason* why it happens so rather than otherwise."

Mexico also, as in Central America, we still discover, beneath a complication of strange observances and bloody rites, the simplicity of Toltican Zabianism. Upon the high altars of Aztec superstition, reeking with the blood of countless human victims, we still find the eternal fire; no longer, however, under the benign guardianship of consecrated virgins, but consigned to the vigilance of a stern and rigorous priesthood. And, as the Inca trusted at his death to be received to the bosom of his father, the Sun, so too did the fiercer Aztec look forward with confidence to eternal existence and beatitude in the "House of the Sun."*

The Natchez and their affiliated tribes were worshippers of the sun, to which they erected temples and performed sacrifices. And from what can be gathered concerning their temples, it is rendered probable that they erected structures analogous to those under notice. They also maintained a perpetual fire, and their chiefs claimed the sun as their father. The chiefs bore the distinguishing title of *Suns*, and united in themselves the priestly and civil functions.—(*Charlevoix, Canada*, Vol. II., p. 273; *Du Pratz, Hist. Louisiana*, Vol. II., pp. 178, 212; *Herriot, Hist. Canada*, p. 508.) The natives of the Barbadoes and the West India islands generally, worshipped the same celestial body in conjunction with the moon.—(*Edward's Hist. W. Ind.*, Vol. I., p. 80; *Davis's Barbadoes*, pp. 216, 236; *Herrara*, Vol. I., p. 162.) The Hurons derived the descent of their chiefs from the sun, and claimed that the sacred pipe proceeded from that luminary.—(*Charlevoix, Canada*, Vol. I., p. 322; *Lafiteau*, Vol. I., p. 121.) The Pawnees, Mandans, and Minatarees had a similar tradition and a kindred worship.—(*Nutall's Arkansas*, p. 276.) The Delawares and the Iroquois offered sacrifices to the sun and moon; and, in common with the southern Indians, had a festival in honor of the elementary fire, which they considered the first parent of the Indian nations. It is probable that their council-fire was an original symbol of their religion.—(*Loskiel*, pp. 41, 43; *Colden's Hist. Five Nations*, Vol. I., pp. 115, 175; *Schoolcraft's Narrative*, p. 20; *Bradford's Res.*, p. 352.) The Virginian tribes were also sun worshippers, and sustained the perpetual fire in some of their temples. The same is true, as we have already had occasion to show, in a remarkable manner, of the Floridian tribes; who, if we are to credit the accounts of the early voyagers, sacrificed human victims to the sun.—(*Ribauld*, MS.; *Le Moyne*, in *De Bry; Herrara, Florida; Lafiteau, Moeurs des Sauvages*, Vol. I., p. 158; *Rochefort, Hist. Antilles*, Chap. 8.)

The Esquimaux, the natives of the Northwest Coast, and the California Indians, all shared in this worship.—(*Hall's Voy.* (1631), pp. 38, 61; *Vanegas's California*, Vol. I., p. 164.) It prevailed to an equal extent among the savage tribes of South America. In connection with the worship of the moon, it existed among the Muyscas of Colombia, among the Araucanians, the Puelches, and the Botucados of Brazil.—(*Herrara*, Vol. V., p. 90; *Molina*, Vol. II., p. 71; *Dobrizhoffer*, Vol. II., p. 89; *Mod. Trav. in Brazil*, Vol. II., p. 183.) The caziques of the Gua-

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* *Clavigero*, Vol. II., p. 3. "They held for an assured faith that there were nine places appointed for souls, and the chiefest place of glory was to be near the sun."—(*Gomera*, in *Purchas*, Vol. III. p. 1137.)

ranies, like those of the Natchez, were called *Suns*, and claimed a like lofty lineage. The evidence upon this point might be greatly extended, but enough has been adduced to establish the general predominance of Sun Worship in America.*

It will be seen, from this hasty survey, that the hypothesis which ascribes to the square, circular, and other regular structures of the Mississippi valley a religious origin, and to their forms a symbolical significance, is sustained not only by the most obvious circumstances of structure and position, but also by striking analogies, derived from the form and known character of corresponding structures in other parts of the world. It is further sustained by the nature of the worship, which, from its wide diffusion and great prominence amongst the American nations, we are justified in supposing was elementary and pervaded the American continent from the earliest period.

It may be objected that a portion of these structures are square or octangular, and cannot, therefore, whatever may be said of those bearing a circular form (and which are by far the most numerous), be regarded as symbolizing the sun, or indicating the prevalence of sun worship among the builders. Any attempts to answer this question would doubtless involve a very extended inquiry into the form and connections which this worship assumed, both in the Old and New Worlds, and would perhaps, after all, bear too much the character of a mere speculation to be satisfactory, or in any degree conclusive. For this reason no attempt of the kind will be made. The observations which follow are thrown out suggestively, as furnishing the possible if not the probable principles upon which some of these structures were built, and the reasons which may have influenced the singular combinations which we observe between them.

It can be shown that the doctrine of the reciprocal principles of nature, which entered so largely into the early idolatry of the Eastern World, prevailed also in America. The sun and the moon, or oftener, the sun and the earth, emblematized these principles. According to Mr. Dudley and other writers on symbolism, these powers among the primitive idolaters were figuratively represented: the male principle by the *circle*, the female principle by the *square*.† The same authorities lay it down as a rule, subject to few exceptions, that whenever the circular form is adopted in sacred structures, the worship of the male principle is indicated; but when the quadrangular, then the female principle. "At one time," says Mr. Dudley, "the ancient world was divided in the worship of the two powers; but time

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* "Sun worship existed extensively in North as well as South America. There is reason to believe that the ancestors of all the principal existing tribes of America worshipped the *Eternal Fire*. Both from their records and traditions, as well as their existing monuments, this conclusion is irresistible. * * * Among the North American tribes, the graphic *Ke-ke-win*, which depicts the sun, stands on their pictorial rolls as the symbol of the Great Spirit; and no important rite or ceremony is undertaken without an offering of tobacco to him. The weed is lit from fire generated anew on each occasion."—(*Schoolcraft, Address before N. Y. Hist. Soc.*, 1846, p. 29.) "They believe in the sacred character of fire, and regard it as the mysterious element of the universe typifying divinity."—*Ib.*, p. 35.

† "The Chinese have consecrated two temples, one to the Heavens, the other to the Earth: the first is round, the second square, according to the theory of their learned men; who, with the Pythagoreans, regard the earth as a *cube*, and the heavens a *sphere*."—(*De Pau, Res. China and Egypt*, Vol. II., p. 42.)

and various circumstances contributed to effect a compromise, which resulted in the combination of the two figures, or the adoption of the octagonal form instead." Mr. Dudley instances several examples of these combinations among the early Grecian and Celtic remains, and observes, "if the sacred structures of early antiquity were examined with reference to this doctrine, many and ample proofs of its truth would be discovered."—(*Naology*, pp. 345, 358, *ubi supra.*)

If we were to adopt the hypothesis advanced by Mr. Dudley, the fact that the American nations almost universally entertained the idea that the earth was square, would become invested with importance.

But, as already observed, these latter suggestions are simply thrown forward as plausible, and not as indicating a settled opinion. The refinement of symbolism which they imply, will, however, appear less improbable, when we come to learn to what extent the semi-civilized nations of America, in their religious beliefs and conceptions, display an identity with the primitive nations of the Old World.

The hypothesis of a symbolical design in the forms and combinations of these structures may seem somewhat new and startling to most minds. There are, however, many other facts and considerations having a direct bearing upon it, which will appear in a succeeding work. Meantime, and before passing to collateral inquiries, it will not be out of place to repeat, that the great size of many of the structures to which we have assigned a sacred origin, precludes the idea that they were temples in the ordinary acceptation of the term. It is probable that, like the great circles of England, the squares of India, Peru, and Mexico, they were the sacred enclosures within which were erected the shrines of the gods of the ancient worship, and the altars of the ancient religion. They may have embraced consecrated groves, and, as they did in Mexico, the residences of the ancient priesthood. Like the sacred structures of the country last named, some of them may have been secondarily designed for protection in times of danger.

STONE-HEAPS—STONES OF MEMORIAL—STONE CIRCLES.

It has been noticed, on a preceding page, that occasional large heaps of stone, owing their origin to the aborigines, are to be found in the State of New York. Particular reference was made to one in Scoharie county, which is described more in detail in Howe's Gazetteer of New York, as follows:

"Between Scoharie Creek and Caughnawaga was an Indian trail, and near it, in the north bounds of Scoharie county, has been seen, from time immemorial, a large pile of stones, which has given the name of 'Stone Heap Patent' to the tract on

which it occurs, as may be seen from ancient deeds. Indian tradition says that a Mohawk murdered his brother on this spot, and that this heap was erected to commemorate the event. Every individual who passed that way added a stone to the pile, in propitiation of the spirit of the victim."—(*Howe's Gaz. of New York*, p. 278.)

Dwight, in his travels, mentions a heap of stones of this description, which was raised over the body of a warrior killed by accident, on the old Indian trail between Hartford and Farmington, the seat of the Tunxis Indians, in Connecticut. Rude heaps of stone of similar character are of frequent occurrence throughout the West. A very remarkable one occurs upon the dividing ridge between Indian and Crooked Creeks, about ten miles south-west of Chilicothe, Ohio. It is immediately by the side of the old Indian trail which led from the Shawanoe towns, in the vicinity of Chilicothe, to the mouth of the Scioto River, and is described in detail in the first volume of these Contributions, p. 184.

Another heap of stones, of like character, but somewhat less in size, is situated upon the top of a high, narrow hill overlooking the small valley of Salt Creek, near Tarlton, Pickaway county, Ohio. It is remarkable as having large numbers of crumbling human bones intermingled, apparently without order, with the stones. A very extensive prospect is had from this point. Upon the slope of a lower hill, near by, appears to have been formerly an Indian village. Many rude relics are uncovered on the spot by the plough.

Smaller and very irregular heaps are frequent among the hills. .These do not generally embrace more than a couple of cart-loads of stone, and almost invariably cover a skeleton. Occasionally the amount of stones is much greater. Rude implements are sometimes found with the skeletons. A number of such graves have been observed near Sinking Springs, Highland county, Ohio; also in Adams county in the same State, and in Greenup county, Kentucky, at a point nearly opposite the town of Portsmouth, on the Ohio.

A stone-heap, somewhat resembling those first described, though considerably less in size, is situated on the Wateree River, in South Carolina, near the mouth of Beaver Creek, a few miles above the town of Camden. It is thus described in a MS. letter from Dr. Wm. Blanding, late of Camden, addressed to Dr. S. G. Morton, of Philadelphia:

"The land here rises for the distance of one mile, and forms a long hill from north to south. On the north point stands what is called the 'Indian Grave.' It is composed of many tons of small round stones, from one to four and five pounds weight. The pile is thirty feet long from east to west, twelve feet broad, and five feet high; so situated as to command an extensive view of the adjacent country as far as 'Rocky Mount,' a distance of twenty miles above, and of the river for more than three miles, even at its lowest stages."

A large stone-heap was observed, a number of years since, on a prairie, in one of the central counties of Tennessee. "Upon removing the stones, near the centre of the pile was found a stone box, six feet long and three broad, formed by joining with care the edges of flat stones. Within it was found the decayed skeleton of a man. No weapons or other relics accompanied the skeleton."

The smaller stone-heaps of the West seem to have been connected with some system of burial, and were perhaps designed to protect the bodies of those who casually met their death among the hills, or in some encounter with an enemy, from the attacks of wild animals, as well as to point out their places of sepulture.* It is still customary among some of the Indian tribes to carefully envelope the bodies of their dead, and place them in trees or on scaffoldings, for the same purpose.†

Occasionally, after interment in the earth, stakes are driven around the graves for the sake of protection. Whether the large heap first described was raised over the body of some distinguished savage, or as a simple mark or monument upon the Shawanoe trail, it is difficult to determine. The absence of human remains would seem to favor the latter conclusion. However this may be, there is certainly nothing very singular in the existence of these monuments. A spot remarkable in any respect, seldom failed to arouse the superstitions of the Indians, or attract their reverence, and to become in time a great "medicine" or mystery. According to Acosta, the Peruvians had a practice of casting a stone as an offering upon any remarkable spot, at the crossings of paths, and on the tops of hills or mountains. "It is therefore," observes our authority, "that we find by

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* "To perpetuate the memory of any remarkable warriors killed in the woods, I must here observe that every Indian traveller, as he passes that way, throws a stone on the place, according as he likes or dislikes the occasion or manner of death of the deceased. In the woods we often see innumerable heaps of small stones in these places, where, according to tradition, some of their distinguished people were either killed or buried, till the bones could be gathered; then they add Pelion on Ossa, still increasing each heap, as a lasting monument and honor to them, and an incentive to great actions."—*Adair's History of the American Indians*, p. 184.

"At or soon after burial, the relations of the deceased sometimes cover the grave with stones; and, for years after, occasionally resort to it, and mourn over or recount the merits and virtues of the silent tenant." —*Hunter's Narrative*, p. 309.

"They have other sorts of tombs; as when an Indian is slain, in that very place they make a heap of stones (or sticks, when stones are not to be found); to this memorial, every Indian that passes by adds a stone, to augment the heap, in respect to the deceased hero."—*Lawson's Carolina* (1709), p. 22.

Long describes an Indian burial-place near Piqua, Ohio, where the dead were placed upon the bare limestone rocks, and covered over with slabs of stone. No order was displayed in the arrangement of the graves. A cemetery of like character, in which each grave is marked by a heap of stones, is said to exist in Westmoreland county, Pennsylvania.

The Bheels of the mountain district of India still raise *cairns*, or rude piles of stones, over the bodies of their chiefs, the tops of which, at particular periods, are covered with oil, red lead, and vermilion.—*Coleman's Hindu Mythology*, p. 271.

† "Among the Blackfeet, the dead are not buried in the ground, if it can be avoided. The body is sewn up in a buffalo robe, dressed in his best clothes, his face painted red, but without his weapons, and laid in some retired place: in ravines, rocks, forests, or on high, steep banks. It is often covered with wood and stones, so that the wolves may not reach it. Frequently the corpse remains above ground in a kind of shed. At the funeral of rich Indians, several horses are often killed on the spot; we were told of instances in which ten and twelve, and even one hundred and fifty, were killed."—*Maximilian's Travels in North America*, p. 259.

the highways great heaps of stones offered, and such other things."* So, too, an early writer on the Housatonic Indians observes: "There is a large heap of stones, I suppose ten cart-loads, in the way to *Wanhktukook*, which the Indians have thrown together as they passed by the place: for it used to be their custom, every time one passed by, to throw a stone upon it; but what was the end thereof they cannot tell, only that their fathers used to do it, and they do it because it was the custom of their fathers. Some suppose it was designed as an expression of their gratitude to the Supreme Being, that he preserved them to see the place again." —(*Hopkins's Memoirs of Housatonic Indians*, p. 11.) The "Elk-horn pyramid," on the Upper Missouri, is regarded with deep reverence, and no hunter passes it without adding another horn to its proportions. This accumulation has been going on for a long period, and the pile is now reported to be not far from fifteen feet high, and of corresponding lateral proportions. It is composed entirely of elk-horns, many of which are to be found upon the adjacent prairies. An instance of this practice of accumulating stones and other materials, is mentioned by Mr. Schoolcraft, in which the offerings consisted of sticks and twigs. It is highly probable that most of the great heaps of stone scattered over the country owe their origin to this practice. It is further possible that some of them may have originated in a practice mentioned by Beverly, who states that the Indians sometimes signalized the conclusion of a peace, or some other memorable action, by burying a tomahawk, and raising over it a heap of stones.—(*Hist. Virginia*, p. 164.) If such was the fact, "burying the hatchet" was not a mere rhetorical figure among the Indian orators.

Customs, similar in all respects to those described as existing among the Indians, prevailed among the ancient Celts, and have hardly become extinct among the Highlanders of Scotland. A *cairn*, or heap of stones, was a common monument of the dead; and hence arose the saying, "*I'll add a stane to yer cairn*," in acknowledgment of a service, or in token of regard. Two motives, however, appear to have existed for throwing a stone, in passing, to a cairn. In the one case, says Logan, it arose from respect to the deceased, whose memory it was wished to prolong by increasing the size of his funeral mount. The soul of the departed was believed to be pleased with this mark of attention. The other motive for throwing stones to augment a cairn was, to mark with execration the burial-place of a criminal; a practice which, according to Dr. Smith, was instituted by the Druids. "It is curious," continues the above author, "that the same practice should result from views so different; yet the fact is so, and the author has often, in the days of his youth, passed the grave of a suicide, on which, according to custom, he never failed to fling a stone." "A *carn* or *cairn*," says O'Connor

* *Acosta*, in *Purchas*, Vol. III., p. 1028. The ancients erected heaps of stones in the crossways, and every traveller augmented it by adding a stone. These were termed *Thermulæ*. The pilgrims of the Middle Ages did the same, when they came within view of the end of their journeys; the piles which they erected were called *Montjoyes*. In the passes of the Alps, rude heaps of stones are visible, marking the spot of some deed of violence, or of some catastrophe.

(*Chronicles of Eri*, *Introduction*, Vol. I., p. 297), " is a heap of stones, upon which an inferior order of priesthood, called Carneach, used to officiate; they are also found on the summits of hills, whereon Breo—that is, fire—blazed for beacons as signals; but they were also the only heaps raised over those who came to a sudden or violent death; and in Ireland, the custom is practised to this day, of throwing a small stone on passing the place where one has been accidentally killed, which was considered so great an evil, that a more bitter malediction could not be uttered than, '*Bi an Carn do leact*,' May the Cairn be thy bed."

We may infer from the following passage, ascribed to Virgil, on a noted robber named *Balista*, that stones were sometimes heaped over the graves of criminals, amongst the Romans, in token of obloquy:

> " Monte sub hoc lapidum tegitur Balista sepultus :
> Nocte, die, tutum carpe viator iter."

At the death of Absalom, we are informed, in execration of his memory, his body was cast into a pit, and a heap of stones raised over him. " And they took Absalom, and cast him into a great pit in the wood, and laid a very great heap of stones upon him; and all Israel fled, every one to his tent."—(2 *Samuel*, xviii. 17.) A similar expression of popular hatred was visited upon the avaricious Achan: " And all Israel stoned him with stones, and they raised over him a great heap of stones."—(*Joshua* vii. 25, 26.)

Nothing can be more certain than that the erection of stones, like the elevation of tumuli over the dead as sepulchral monuments, was the first and simplest means of commemorating events. And it is not unlikely that worship was often paid to such as were of ancient date, not so much on the score of symbolical significance, as in consequence of long association with interesting or important circumstances. Monuments of this kind were perpetuated at so late a date, upon the old continent, as to become charged with inscriptions declaring to us the objects for which they were erected. Olaus Magnus observes of Scandinavia, " There are also high stones: by the aspect and signature thereof the ancient possessions of provinces, governments, forts, communities of men, are to continue to every man in peace, without laws, suits, or arbitration; giving an example that among these nations there is more right to be found in these stones, that are boundaries, than elsewhere in the large volumes of laws, where men think themselves more learned and civil."

The first instance, recorded in the Bible, of the erection of such stones, is that of Jacob, who raised a stone at Bethel, to commemorate the vision which he saw, and attest the engagement which he formed in consequence. In fixing their respective boundaries, Laban said to Jacob, " Behold this heap, and behold this pillar, which I have cast up betwixt thee and me. This heap be witness, and this pillar be witness, that I will not pass over this heap to thee, and thou shalt not pass over this heap and this pillar to me for harm."—(*Gen.* xxxi. 51, 52.) In reading this account, it is impossible to resist the conviction that the parties were

not originating a new practice, but acting in conformity with usages well known and established. The stone set up by Joshua under the oak at Shechem, was assuredly an evidence and memorial of the covenant into which he had entered with God. The incidental references to stones of this kind, in the Bible, show that they were numerous. Thus, there is "the stone of Bohan the son of Reuben" (*Josh.* xviii.), and the great stone known as "the stone of Abel," upon which the ark was placed in returning from the Philistines.—(1 *Sam.* vi.) The Hebrews also set up stones as monuments of victories; such was the *Ebenezer*, "the stone of help," set up by Samuel.—(*Sam.* vii.) Greek historians inform us that a similar custom existed among that people, derived from their ancestors. Every memorable field of battle throughout Greece has its tumulus or *polyandrion.*

Among the aborigines of America, stones were sometimes erected for precisely similar purposes. We have an instance, mentioned by Col. Emory, in which an erect stone was raised by some of the Indians of Northern Mexico, in commemoration of a treaty or compact. He says: "At this point (on the plains bordering the Moro River, New Mexico), we were attracted to the left by an object which we supposed to be an Indian; but on coming up to it, we found it to be a sandstone block standing on end, surmounted by another shorter block. A mountain man, versed in these signs, said it was in commemoration of a talk and friendly smoke between some two or three tribes of Indians."—(*Military Reconnoissance from the U. S. to California.*)

The superstitions of the Indians exhibit themselves in a thousand forms, and extend to almost every remarkable object in nature. A stone which, from the action of natural causes, has assumed the general form of a man or an animal, is especially an object of regard; and the fancied resemblance is often heightened by artificial means, as by daubs of paint, indicating the eyes, mouth, and other features. Mr Schoolcraft has presented the public with sketches of a number of

Fig. 43.

these rude idols, all of which were found to the north-west of the Great Lakes. No. 1 in the cut was brought to the Indian Office at Mackinaw, in 1839; number 2 was found on Thunder Bay Island, in Lake Huron, in 1820, where it had been set up under a tree. The island is small and barren, and in its solitary, desolate aspect furnished a place eminently appropriate, according to the Indian supersti-

tion, for the residence of a Manitou or spirit. No. 3 was found by Mr. Schoolcraft, about one thousand miles above the Falls of St. Anthony, on the Mississippi. It had been set up in a shadowy nook, and was almost entirely concealed by shrubbery.—(*Indian in his Wigwam*, p. 292.) Fig. 44, No. 1, was found in East

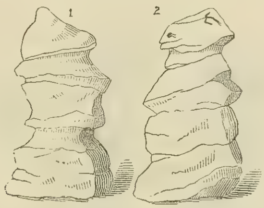

Fig. 44.

Hartford, Connecticut, and deposited in the Museum of Yale College in 1788. It is thirty-one inches high and seventeen wide; the material is white granite. It is said the Indians placed their dead before it previous to burial, and afterwards returned and danced around it.—(*Trans. Am. Acad. Arts and Sciences*, Vol. III., p. 192.) Number 2 was found at the base of a mound in South Carolina, and is now in the possession of Dr. S. G. Morton, of Philadelphia. It is small, not more than six inches in height, and has evidently undergone some artificial modification.

Single erect stones, or a group of them, of large size, in isolated situations, were also venerated. They are sometimes covered with rude figures, and sacrifices made at their base. James, Lewis and Clarke, Prince Maximilian, and other travellers mention some of these, which in size and general disposition closely resemble the Celtic *cromlech*—(*Lewis and Clarke*, pp. 79, 83; *Prince Maximilian's Travels*, pp. 381, 417; *James's Narrative*, Vol. I., p. 252.) Catlin observed a singular group of five large boulders, at the *Coteau des Prairies*, which were regarded with the utmost veneration by the Indians. None venture to approach nearer than three or four rods; and offerings are made in humble attitude, by throwing tobacco towards them from a distance.—(*N. A. Indians*, Vol. II., p. 202.)

In the State of New York also, at various points, are remarkable stones, with which the Indians connected their traditions, and which they were accustomed to hold in high regard. Such was the celebrated "Oneida Stone," from which the Oneidas figuratively represent themselves to have sprung. It stands in the town of Stockbridge, Madison county, on a very commanding eminence, from which the entire valley, as far as Oneida Lake, can be seen, under favorable circumstances. It was the altar of the tribe, and a beacon-fire lighted near it was the signal for the warriors to assemble in cases of emergency. It is a large boulder of sienite, and is figured by Mr. Schoolcraft, in his "Notes on the Iroquois," p. 77. In the county of Westchester, town of Yonkers, on the bank of the Hudson, in an obscure nook, is also a singular stone, which once received the reverence of the Indians. Another, bearing some resemblance to the human head,

is found in the town of New Rochelle, in the same county.—(*Hist. County of Westchester*, By Robt. Bolton, Jr., Vol. I., p. 374: Vol. II., p. 403.) In the township last named is also a very remarkable rock, supported by five others, as shown in the following wood-cut, Fig. 45:

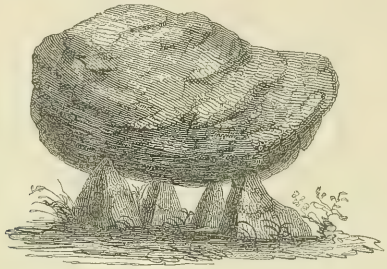

Fig. 45.

From its entire correspondence with the Celtic *cromlech*, this has attracted some considerable attention. Its position is, however, entirely the result of accident. The rock itself is granite, and the supporting stones limestone. The members of the New York Geological Survey decided that it owes its position to the washing away of the earth from among the stones upon which the boulder accidentally rested when transported to this spot.—(*Ib.*, Vol. I., p. 374)

It is well known that among the nations of the East, a plain, unwrought stone placed in the ground, was an emblem of the generative or procreative powers of nature. In India such such stones are very abundant, and are denominated Lingams; and in Central America the same symbol was extensively adopted. It is not improbable that the erection of an obelisk of wood in the centre of the consecrated areas of the Creeks, as described by Bartram, on page 135, had its origin in the primitive practice of erecting these symbolical stones; which in India, as also in Central America, almost invariably occupy the centres of the sacred enclosures. Stones arranged in a circle, around a central larger one, or amidst several disposed in a peculiar manner, was a very primitive form of the solar temple. The remains of these temples, notwithstanding their rudeness, constitute some of the most imposing and interesting monuments of the Old World. If we may credit Beverly, the Indians of Virginia not only erected sacred stones, but had sacred enclosures, corresponding very nearly with the ancient stone circles. He says: "The Indians have posts fixed around their *Quioccasan* (temple of the idol), which have men's faces carved upon them, and are painted. They are likewise set up around some of their other celebrated places, and make a circle for them to dance about in on certain solemn occasions. They very often set up pyramidal stones and pillars, which they color with *puccoon* and other sorts of paint, and which they adorn with *peak*, *roanok*, etc. To these they pay all outward signs of worship and devotion, not as to God, but as they are hieroglyphics of the permanency and immutability of the Deity; because these, of all sublunary

bodies, are the least subject to decay or change: they also, for the same reason, keep baskets of stones in their cabins."—(*Hist. Virginia*, p. 184.)

Besides the rough, upright, and wrought stones, constituting enclosures, or occupying the areas of sacred structures, in Central America and Yucatan, accounts of which are given by Mr. Stephens, we have intelligence of the recent discovery of monuments in New Granada (South America), which exhibit a still closer relationship to the primitive stone circles and other analogous structures of the other continent. The subjoined account is given in a letter from Signor Velez, dated Bogota, December, 1846:

"In traversing, at different times, the province of Tunja, with the sole purpose of examining the country, I acquired some vague information respecting the presumed existence, in the province of Leiva, of some ruins belonging to a temple or a palace of the times of the ancient Indians. As the account varied each time that I attempted to inform myself by inquiries as to the existence of remains of buildings anterior to the conquest, and as no one affirmed that he had seen them himself, I began to doubt the truth of the report. Nevertheless, as the subject was one that interested me exceedingly, I undertook a journey, in the month of June, 1836, in spite of the time and trouble it would necessarily cost me, in order to put an end to my uncertainty. After traversing the province of Leiva in different directions, without meeting with the object I was in search of, and after advancing as far as the neighborhood of Moniquira, by following the route from Gachantiva to this place, across a beautiful gently sloping plain under cultivation, I discovered a large stone, which, when seen some distance off, did not at first appear as if wrought by the hand of man. On approaching it, I found it was a sort of column, four and two-sixths varas in length by three and one-half in diameter. It seemed to me that such stones, although rudely wrought, must have served as columns. On examining the locality, I found, scattered here and there, other stones similar to the first: and at last, thirteen stones of the largest size, ranged as in a circle about fifty varas in circumference. It appeared to me that they must have proceeded from some temple or palace, extending back to a remote period. Some of these columns have a flattened shape, like a fish; each has notches at its extremeties, which show clearly what means were employed for making fast to them and drawing them from the quarry to the site which they now occupy.

"But now, when I began to despair of meeting with the ruins of an edifice, which was the main object of my journey, some Indians from a hut pointed out to me a spot some four hundred varas distant from the thirteen last mentioned columns. I immediately proceeded thither, and great indeed was my joy at beholding ruins! I found cylindrical columns, exceedingly well wrought, fixed in the ground, and occupying a surface forty-five varas long by twenty-two broad. These ruins extend, in the direction of their length, from east to west; some arranged in a straight line running in the same direction, with this peculiarity, that the columns are so near together that their distance from each other does not exceed half a vara. Their circumference also is not over half a vara (*sic*). As to their length, it could not be determined, these remains being so much damaged,

that the highest of them is not more than one and a-half varas above ground; others are scarcely visible, the ranges to which they belong being interrupted. The diameter of these columns is precisely alike; they resemble each other exactly, and are so well turned into a cylindrical shape, that they seemed to me of better workmanship than those now made use of at Bogota; they form, by their lightness and elegance, a striking contrast with the thirteen enormous fragments mentioned above.

"It is impossible to affirm that the edifice in question was only forty-five varas long and twenty-two broad; because, in this space, the columns touch each other. Over the whole extent of the place, which covers a considerable surface, there are scattered numerous fragments of columns, as also of other stones, which appear to have been wrought on one of their faces. At a distance of one hundred varas, I also found a spot covered with brambles and a considerable number of stones, which, from a cursory examination, I concluded to have been wrought. The columns which remain sunk in the ground are about twenty-nine in number.

"In all that I saw, I observed no trace of mortar, lime, or any other cement. By taking up some of these columns, some may perhaps be found.

"The examination of these vestiges made a deep impression upon me; and I became convinced that the territory which contains them, and which is about two miles in extent, must have been occupied by a large city, and as I conclude, by a nation much more ancient than the Muyscas.

"The ignorance which has always reigned in the province of Tunja, explains the little attention shown to monuments so interesting, and so worthy of being studied. The inhabitants of the country have alone been acquainted with them up to the present time; and although not comparable in importance and grandeur to those which have been discovered in Guatemala and Yucatan, they nevertheless attest the existence of ancient populations already far advanced in civilization."

Monuments analogous to those here described are found on the shores of Lake Titicaca, in Peru. Their origin is lost in obscurity, and they are supposed, by M. D'Orbigny, who has carefully investigated and given the world drawings of them, to have been the work of a race anterior to the Incas; denoting, perhaps, a more advanced civilization than the monuments of Palenque. They have been described by a number of the early writers, commencing with Pedro de Ceica, one of the followers of Pizarro. M. D'Orbigny speaks of them as follows: "These monuments consist of a mound raised nearly a hundred feet, surrounded with pillars; of temples from six to twelve hundred feet in length, opening precisely toward the east, and adorned with colossal angular columns; of porticoes of a single stone, covered with reliefs of skilful execution, though of rude design, displaying symbolical representations of the sun, and the condor, his messenger; of basaltic statues loaded with bas-reliefs, in which the design of the carved head is half Egyptian; and lastly, of the interior of a palace formed of enormous blocks of rock completely hewn, whose dimensions are often twenty-one feet in length, twelve in breadth, and six in thickness. In the temples and palaces, the portals are not inclined, as among those of the Incas, but perpendicular; and their vast

dimensions, and the imposing masses of which they are composed, surpass in beauty and grandeur all that were afterwards built by the sovereigns of Cuzco."—(*L'Homme Américain*, Tome I., p. 323.)

Structures like those, the ruins of which are here described, on the eastern continent, were almost invariably of religious origin, and dedicated to sacred purposes. And as the priestly and civil offices in early and patriarchal times were usually conjoined, it not unfrequently happened that the rude temples were places of judicature. They had also sometimes a monumental significance; that is to say, were erected by some chieftain or powerful individual at places which had been signalized by some important event,—a delivery from danger, or a victory, in accordance with a vow, or as a grateful acknowledgment to overruling powers. Not long after the delivery of the Law at Mount Sinai (says Kitto), the people entered into a solemn covenant with God. On this occasion Moses built an altar of earth at the bottom of the mountain, and erected around it twelve stones, corresponding to the twelve tribes.—(*Exod.* xxiv. 4.) This rude open temple was the type of the great temple afterwards erected at Jerusalem; and the principles involved were, in both cases, the same. An example of the erection of stones as sacred memorials, is afforded in the account of the passage of the Jordan at Gilgal. The object is specifically declared: "That this may be a sign among you; that when your children ask, in time to come, saying, What mean ye by these stones? Then ye shall answer them: The waters of Jordan were cut off, and these stones are for a perpetual memorial to the Israelites." The term Gilgal implies a circle or wheel, and indicates the probable manner in which the stones of memorial were arranged.

As we have said, sacred places, the residences of the priests, etc., were anciently also places of deliberation and judicature, where nearly every affair of public importance was transacted. Gilgal seems to have been devoted to all of these purposes. The first "Messenger" or prophet which we read of in the Bible, as being sent on a special mission, came from Gilgal (*Judg.* ii. 1), a circumstance which seems to imply that it was a station where priests or prophets resided to perform specific duties. And it is remarkable that the places where Samuel held his courts of judicature, in his annual circuits from his residence at Ramah, were places of sacred stones. "He went from year to year in circuit to Bethel [the place of the sacred stone set up by Jacob], and Gilgal, and Mizpeh, and judged Israel in all these places."—(1 *Sam.* xii. 16.) Mizpeh was the name of the place of the stones set up by Jacob and Laban. It was almost equal with Gilgal as a place of public transactions. Here the tribes met at the call of the Levite, to deliberate on the war against Benjamin (*Judg.* xx. 1); and here Samuel convoked the solemn national assembly of repentant Israel.—(1 *Sam.* vii. 5–12.) It was so well known as a place of public gathering, that the Philistines no sooner heard of the assembling, than they marched against it. Here, too, Samuel called the people together to elect a king.—(1 *Sam.* x. 17.)

There seems to have been an altar at Gilgal; for that burnt-offerings and other sacrifices were made there, is manifest from Samuel's direction to Saul. "Go down before me to Gilgal; and behold I will come down to thee, to offer burnt-offerings, and to sacrifice sacrifices of peace-offerings."—(1 *Sam.* x. 8.) Here

Saul was inaugurated as king on a subsequent occasion. And after Saul's victory over the Ammonites, "Samuel said to the people, Let us go down to Gilgal, and renew the kingdom there. And all the people went to Gilgal, and there they made Saul king before Jehovah in Gilgal; and they sacrificed peace-offerings before Jehovah, and there Saul and all the men of Israel rejoiced greatly."—(1 *Sam.* xi. 14, 15.) Here Saul afterwards gathered the people to war against the Philistines, and, after waiting for Samuel, himself offered sacrifices.—(1 *Sam.* xiii. 4, 7, 12, 15.) It was under pretence of sacrificing them to Jehovah in Gilgal, that Saul spared the choice cattle of the Amalekites. And it was "before Jehovah in Gilgal," that Samuel hewed Agag in pieces. This place also seems to have been the customary residence of the prophet Elijah, which confirms the suggestion that there was some establishment of the prophets here.—(2 *Kings* ii. 1.) In the later prophets there are many denunciations of the corruptions of which Gilgal ultimately became the seat.—(*Amos* iv. 4; v. 5; *Hosea* iv. 15; ix. 12; xii. 11.) It is sometimes coupled in condemnation with Bethel, another place of sacred stones, which shows that these places had become devoted to idolatrous purposes.

Another instance of the erection of stones is afforded in the account of the great solemnity at Ebal and Gerizim. In this case, "great stones" were set up, covered with inscriptions from the word of the Law; and with them was raised the primitive altar of unhewn stones.

The resort to their places of unhewn stones, amongst the Hebrews, indicates the ideas which seem universally to have been connected with such monuments. It is probable that their religious use formed the primary idea in their construction, and that their civil use was secondary, or rather, involved in the other; and it also seems likely that after the religious notions connected with structures passed away, they long continued to be appropriated to civil purposes.

Homer more than once alludes to councils as being held within or near circles of stones. The remarkable passage in the Iliad (xviii., l. 585), may be mentioned. It is thus translated by Mr. King: "The herald at length appeased the tumult; and the elders sat at rough hewn stones, within a sacred circle." So, too, the council, summoned by Alcinous to confer upon the affair of Ulysses, sat at rough hewn stones—(*Odyss.* viii. 5.)

Abundant facts may be produced showing the use of stone circles at various occasions, as of inaugurations and councils, as late as the fourteenth century, in the north of Germany, Sweden, Denmark, and the Western Islands. And Pinkerton (*Des. of Empire*, 1802) says, "the Icelandic writers tell us that such circles were called *domh-ringr*, that is literally, *doom-rings*, or circles of judgment, being the solemn places where courts were held for various purposes." And Olaus Magnus (1550) mentions that the practice of crowning kings at such places was continued in his day. A circle of stones called *Morasten*, near Upsal, Sweden, was the spot appropriated, from immemorial time, for that purpose.—(*Hist. of the Goths*, pp. 12, 13.) Sir R. C. Hoare observes of the stone circles and similar monuments of the British islands, that there is abundant evidence that "the circle, the enclosure, and the mound, such as we see at Abury, Marden, and Stonehenge, were connected first with the Druidical and afterwards with the Bardic systems, and

made use of for the joint purposes of religion and judicature." Cæsar, writing of the Druids, is understood to allude to their sacred structures in the following passage: "Once a year the Druids assemble at a consecrated place. Such as have suits depending, flock thither from all parts, and submit implicitly to their decrees." —(*De Bello Gallico*, Lib. VI.) The Bardic successors, who preserved and transmitted in writing many of the ideas and usages of their predecessors, speak of their sacred mounts and circles in distinct terms. Meagant, who wrote in the seventh century, says that they had their sacred mount where the judges assembled to decide the causes of the people.—(*Davies' Myth. of the Druids*, p. 6.) In a poem by Cynddela, we find, "Bards were constituted the judges of excellence, and bards will praise thee, *even Druids of the circle*, of four dialects, coming from the four regions; *a bard of the steep mount* will celebrate thee." In another passage he exclaims, "It is my right to be master of song, being in a direct line of the true tribe, *a bard of the enclosure*."

These illustrations might be extended through nearly all the early nations of the world, upon both continents. They strikingly confirm the identity in the early practices and primitive notions of mankind.

ADDITIONAL MONUMENTS IN NEW YORK.

ONONDAGA COUNTY.

Since the foregoing pages were printed, a work on the early history of what is popularly called the "Onondaga Country," has been published by Mr. J. V. H. Clark, of Manlius, Onondaga county. Mr. Clark's attention having been specially directed to the subject, he has collected, with great industry, a large amount of information respecting the antiquities of that interesting region, which are embodied in his work; and from this are condensed the subjoined facts, additional to those heretofore presented.

In reference to some aboriginal remains in the town of Elbridge, which are probably those to which Mr. Clinton alluded, as occuring in the same township, Mr. Clark observes:

"Upon lot 81, N. E. part, on land now occupied by Mr. John Munro (previously the Judge Munro farm), was formerly a fort, situated on high ground. In 1793, the ditch and embankment were easily to be traced. Large trees stood upon the wall and in the ditch. The work was square, except that the line of embankment toward the west curved slightly outward. The area was about an acre and a

quarter. The walls were about two feet high; the gateway opened toward the west, and was twelve feet wide. It was situated on a beautiful eminence, nearly surrounded by ravines."

"About half a mile N. W. of this work," continues Mr. Clark, "on what is called the Purdy lot, was another work, of larger dimensions, containing about four and a half acres of ground. It is situated upon one of the most considerable elevations of the town, and is nearly or quite square, with gateways opening to the east and west. The embankment was originally about three feet high, and an oak tree, two feet in diameter, was standing upon it. On the south side were numerous holes, about two feet deep and six feet apart. Large quantities of broken pottery and fresh water shells are still to be found. An oaken chest was discovered here, somewhere about the year 1800, which contained a quantity of silk goods. The folds and colors were easily distinguishable, but the fabric crumbled on exposure. Some copper coins, it is said, were found with the silks.

"On lot 84, on the farm now owned by Mr. Caleb Brown, about forty rods south of the road, was formerly a circular work, of upwards of three acres' area. The embankment was about two feet high, the ditch exterior and four or five feet deep. There was a wide gateway upon the west side, and a smaller one on the northeast, opening toward a spring, some rods distant. In digging near the western gateway, fragments of timber, bearing marks of edge tools, were found; and in an excavation called a well, fourteen feet deep, a quantity of charred Indian corn was discovered. Upon the site of Mr. Brown's house and garden, was also an ancient circular work, enclosing about an acre of ground. Within it were cinders, charcoal, etc., as if it had been the site of a blacksmith's shop."

Mr. Clark describes another ancient work, "situated on a hill, about a mile and a half south of Delphi, in this township, on lot No. 100. It has an area of about eight acres, and occupies an elevated piece of ground, surrounded by a ravine made by two small streams which pass around it and unite on the north. It had a large gateway upon the south, and a smaller one on the north. Before the first was a kind of mound. The defences consisted of a ditch and pickets. At every place where a picket stood, a slight depression is still distinctly visible. In one corner were evident marks of a blacksmith's shop, including various smith's tools, a bed of cinders, and a deposit of charcoal. Beneath one of these piles was found, *en cache*, a quantity of charred Indian corn, and squash and pumpkin seeds. A short distance to the south of the work is an extensive cemetery, in which the bodies were buried in rows." Quantities of the implements and trinkets introduced among the Indians, at the period of the first European intercourse, are found with the skeletons. The palisades were set in the bottom of the ditch, which, when first known, was six feet deep. About a mile west from this are the remains of another work of similar character; and about a

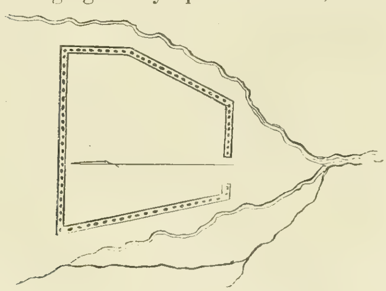

FIG. 46.

mile north of Delphi, on a farm owned by a Mr. Sheldon, is still another. Around a number of these works, the corn hills of the Indians could be traced for a long period after the occupation of the country by the whites. Medals, crosses, gun-barrels, knives, axes—in short, every variety of article introduced by the Europeans after the discovery, are to be found here in abundance.

Perhaps the most interesting work of which any traces yet remain in Pompey township, is the one of which Mr. Clark gives the accompanying plan, and which occurs on lot No. 3, on land owned by Mr. Isaac Keeler.

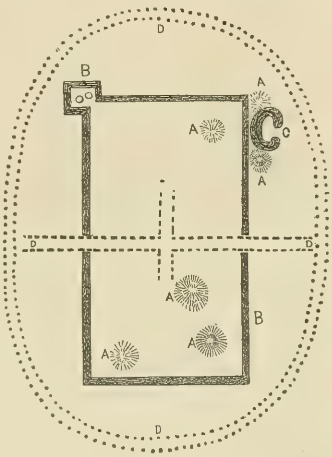

Fig. 47.
B, parapet—A, mounds—C, look-out—D, palisades.

Mr. Clark describes this work as follows: "It had been enclosed with palisades of cedar, and contained some ten acres of ground. The plan was a parallelogram, divided by two rows of palisades, running east and west, and crossing in the centre. The space between the rows was about twelve feet. At the N. W. corner was an isolated bastion and an embrasure. At the period of the first cultivation of the land, many stumps of the palisades, which had been burned off even with the ground, were ploughed up. Within the southern division of the fort were several mounds, the principal one of which was four feet high, rising on a base of about fifteen feet in diameter, composed chiefly of ashes, in which were found many beads of the size of bullets, and a great variety of trinkets made of red pipe-stone. Several hundred pounds of old iron, consisting of axes, gun-barrels, files, knives, etc., etc., were also found in the same place. The smaller mounds contained charred corn, many bushels of which were ploughed up. At a distance of about thirty rods north of the work was a ditch, nearly forty rods long, and varying from three to six feet in depth. It seems to have been entirely disconnected from the work in question. The situation of this ancient fort is on an elevation of land rising gradually for about a mile in every direction; and, at the time of its occupancy, several hundred acres of land must have been cleared around it. Fragments of pottery, pipes, flint arrow-heads, stone hatchets, etc., etc., are abundantly found on this spot. In many places, both within and exterior to the work, were found pits for hiding corn and other articles, *en cache*." Some small mounds containing human bones are found on the lands of Mr. S. A. Keene, in this vicinity.

A relic of some interest, and which has given rise to no inconsiderable speculation, is a stone bearing an inscription, found in this township in 1820, by Mr. Philo Cleveland. It is about fourteen inches long, by twelve broad, and eight thick, granitic, and bearing upon one side a rude representation of a tree, entwined by an equally rude representation of a serpent, with some letters and a date, as shown in the cut.

There seems to be little doubt that the stone was found as represented, and that it is a genuine remnant of antiquity. Some have supposed it to attest that Ponce de Leon, Narvaez, or some other Spanish adventurer, penetrated thus far to the northward, during the period of Spanish adventure in Florida. The stone is now in the museum of the Albany Institute.

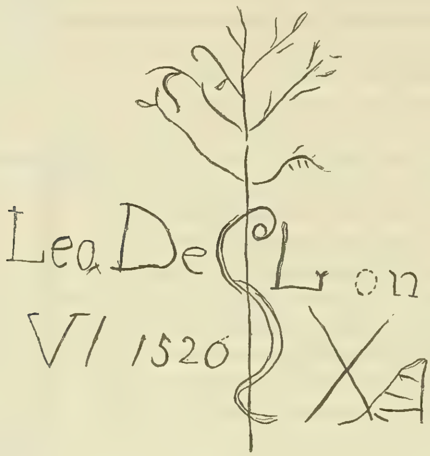

Fig. 48.

Mr. Clark presents the following plan of a stockade work, surveyed by Judge Geddes, and probably the very one referred to by Mr. Marshall, on page 31 of this memoir.

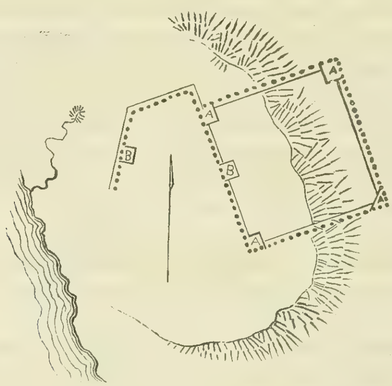

Fig. 49.

It is situated on the shores of Onondaga Lake, between Brown's pump-works and Liverpool. A fine spring of water rises near it; and quantities of relics, of various kinds, have been found within it.

There are yet traces of an old palisaded work in the township of Cazenovia, Madison county, about two miles north of Delphi, of which Mr. Clark gives the accompanying plan, Fig. 50.

It will be observed that it essentially corresponds with those in Onondaga county, already described. It has an area of about five acres; and numerous graves of the Indians are to be found both within and without the walls, in the vicinity.

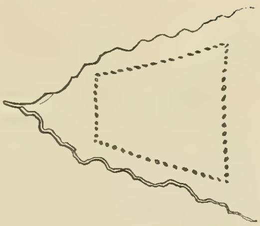

Fig. 50.

ST. LAWRENCE COUNTY.

In addition to the ancient remains found in St. Lawrence county, and described in the foregoing pages, we have the subjoined notices of others, contained in a communication made to the Board of Regents of the University of New York, by F. B. Hough, M. D., of St. Lawrence, and published in their annual Report for 1850, pp. 101, 110:

"In the town of Macomb, St. Lawrence county, are found three trench enclosures, and numerous places where broken fragments of rude pottery, ornaments of steatite, and beds of charcoal and ashes, indicate the sites of Indian villages. It may be proper to state that this region was not inhabited at the time of its first settlement by the whites.

"One of these ruins is on the farm of William P. Houghton, near the bank of Birch creek, and is the one which has furnished the greatest quantity of relics. Beads of steatite, pipes and broken utensils of earthenware, the bones of fish and wild animals, shells, etc., occur, mixed with ashes and bits of charcoal, throughout the soil, within and without the limits of the trench, and have been collected and carried off in large quantities. Cultivation has nearly obliterated every trace of the

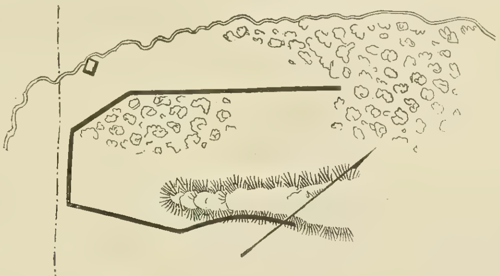

Fig. 51.

enclosure; but by the aid of several persons who were acquainted with the locality when first discovered, the accompanying plan has been drawn, which is believed to represent the situation and extent of this work, before the land was tilled.

"The ground formerly occupied by the trench, is at present the site of an orchard, and used as a mill yard. Reference to this work is made in several

Gazetteers and "Historical Collections," as occuring on the farm of Capt. Washburn, in Gouverneur, (the former owner of the land, before the erection of the township of Macomb,) and in these it is erroneously stated that rude remains of sculpture occur within the enclosure. No traces of sculpture (except the beads, pipes, and other articles) have ever been found here.

"About half a mile northeast of this place, is the trace of another enclosure, but so obliterated by cultivation, that it could not be surveyed with any degree of certainty. It occurs on the farms of Josiah Sweet and William Houghton, the greater portion being upon the farm of the latter. It is situated on a small stream, the outlet of a tamarack swamp, formerly a beaver meadow; is of an irregular oval figure, and can be traced with tolerable accuracy about one hundred and sixty paces, which is nearly half of the original circumference. It longest direction was N. N. E. and S. S.W. Numerous fire-beds occur within the enclosure; and in one instance, a quantity of ashes and charcoal was found five feet below the surface. In a field a few rods distant, large quantities of broken pottery, and traces of an Indian village, are found. About three fourths of a mile from the enclosure first

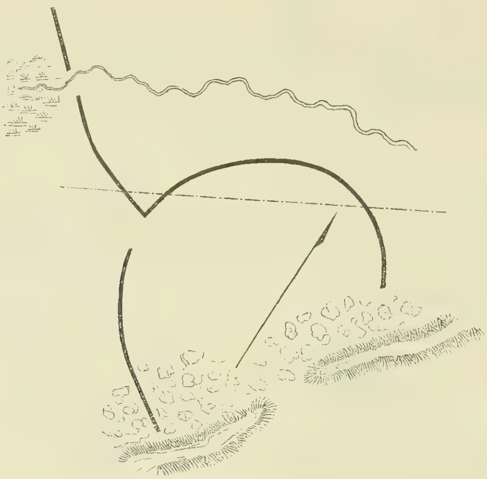

Fig. 52.

described, there occurs another trench, of semi-circular form, and in a far more perfect state of preservation than either of the others. This is on the farm of Robert Wilson, and about twenty-five rods south of "Wilson's Lead Mine."

"For the topography and extent of this trench, reference is made to the accompanying plan, Fig. 52.

"As the land around this has never been ploughed, it has not furnished any relics of interest.

"In the town of Massena, St. Lawrence county, is an ancient enclosure, on the farm of Josiah C. Bridges, about half a mile southwest of the bridge over the

Racket river. It is on a considerable eminence, about half way between the Racket and Grasse rivers, and three miles from the mouth of the latter. The hill may be fifty feet higher than either river; the ancient work is on the southern declivity of the hill, near the top, and the outer ditch may enclose perhaps an acre. It is nearly square, with the corners projecting beyond the line of the sides; from which it may perhaps be inferred that it was a defensive work, and belonged to a different period from the circular works above described. The bank, when first discovered, was surrounded by a ditch about three feet wide, and between one and two feet deep. In the ditch were the remains of old pine trees, some of which must have been at least five hundred years old. Within the enclosure were two elevations, about fifteen feet square, and two feet above the level of the surrounding ground. The location commands a prospect of the country around, in every direction, to a considerable distance.

"In Potsdam, St. Lawrence county, there existed, on the first settlement of the country, a work similar to the one last described, but which is now nearly obliterated by the plough. It was on the west side of Racket river, about half way from Potsdam village to Norfolk. Like the other, it was situated near the top of an elevation, conspicuous from all the surrounding country. Like it, also, it was quadrilateral; its size was nearly the same, and the vicinity of both furnishes numerous remains of rude pottery, stone axes, flint arrows, and various ornaments wrought in steatite. The location in Potsdam is about eighteen miles distant to the southwest from that in Massena; and there is little doubt but that one might be seen from the other, if the the intervening timber were cut away.

"The foregoing are the only remains of ancient art which the writer has been able to learn of in St. Lawrence county, after making the most diligent inquiries."

ESSEX COUNTY.

The following passages are extracted from a private letter addressed to the author, by P. W. Ellsworth, M. D., of Hartford, Connecticut: "In the summer of 1848, while passing through the town of Keene, Essex County, New York, my attention was arrested by what was instantly recognised as a mound, identical in form with those found at the West. No notes were taken at the time, and in giving you an account of it, I must trust entirely to memory; but there is little danger of error, as Dr. A. Smith, at this moment at my side, was then with me. We did not go upon the tumulus, but had a distinct view of it from the road, a few rods distant. It was situated near a little stream, in a large, level meadow, which was surrounded on every side by high ground. It was about fifteen or twenty feet high, with a proportionate base, and rose rapidly, with a graceful curve, from the plain, forming a regular cone. Upon inquiry, I ascertained it was considered to be of Indian origin; that it had been partially excavated by money-diggers, but found to contain nothing beyond human bones. It attracted my special attention, from the circumstance that I supposed no monuments of the kind occurred to the eastward of the Alleghanies."

CHENANGO COUNTY.

It has already been observed that very few entire vessels of aboriginal pottery have been recovered in the State of New York. Their general form is, however, sufficiently evident from the fragments which cover the site of every ancient town. Figure 53 is a sketch of a vessel or vase found in 1811, in Township No. 10, Chenango County. It was buried in the earth, in an inverted position. The capacity was about three quarts. The original drawing was published by Dr. Hosack, in the "New York Medical and Philosophical Register" for 1812. The form, as will be seen by reference to the first volume of these Contributions, p. 189, is that which seems to have been common to all the rude tribes within the boundaries of the Northern and Eastern States. A few of the aboriginal vases had bat bottoms, but most were oval or rounded. The groove around them was designed to receive a withe, whereby they could be suspended over the fire.

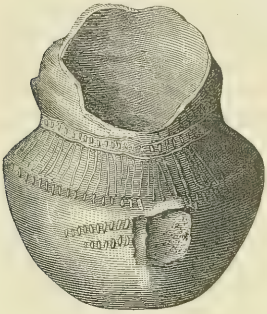

Fig. 53.

USE OF COPPER BY THE AMERICAN ABORIGINES.

In the paragraphs relating to St. Lawrence county, mention is made of a singular aboriginal deposite or burial, on the Canadian shore of the St. Lawrence River, near Brockville. Here were found a number of skeletons and a variety of relics, among which were a number of copper implements. They were buried fourteen feet below the surface of the ground. Two of the copper articles were clearly designed as spear-heads: they were pointed, double-edged, and originally capable of some service. One was a foot in length. A couple of copper knives accompanied these, and also an implement which seems to have been designed as a gouge.—(*Ancient Monuments of Mississippi Valley*, p. 201.) Some implements entirely corresponding with these have been found in Isle Royal, and at other places in and around Lake Superior. Whether or not these are relics of the existing Indian tribes, it is not undertaken to say, although it seems highly probable that they are. That the Indians of New England, New York, and Virginia, to a limited extent, possessed copper ornaments and implements at the time of the Discovery, is undoubted; but it is not to be supposed for an instant that they obtained it by smelting from the ores. They unquestionably procured it from the now well known native deposites around Lake Superior.

Raleigh observed copper ornaments among the Indians on the coast of the Carolinas; and Verazzano mentions articles, probably ornamental, of wrought copper, among the natives which he visited in a higher latitude, "which were more esteemed than gold." Granville speaks of copper among the Indians of Virginia, which was said to have been obtained among the *Chawanooks* (Shawanoes?). "It was of the color of our copper, but softer." He endeavored to visit the place where it was represented to be found; but after a toilsome journey of some days into the interior, the search was abandoned. This was a grievous disappointment at that time, when the minds of men were filled with visions of vast mineral wealth, and when the value of the New World was thought to consist in its mines. Granville thus concludes his account of his fruitless expedition: "I have set down this voyage somewhat particularly, to the end that it may appear unto you (as true it is) that there wanted no good will, from the first to the last of us, to have perfected the discovery of this mine; for that the discovery of a good mine, by the goodness of God, or a passage to the South Sea, or some way to it, and nothing else, can bring our country in request to be inhabited by our people."—(*Granville's Voy.*, 1585, in *Pinkerton*, Vol. XII., p. 580.) Heriot says, "In two towns 150 miles from the main, are found divers small plates of copper, that are made, we are told by the inhabitants, by people who dwell farther in the country, where, they say, are mountains and rivers which yield white grains of metal, which are deemed to be silver. For the confirmation whereof, at the time of our first arrival in the country, I saw two small pieces of silver, grossly beaten, about the weight of a *tester*, [an old coin about the weight of a sixpence sterling,] hanging in the ears of a Wiroance. The aforesaid copper we found to contain silver."—(*Heriot's Voy.*, 1586, in *Pink.*, Vol. XII., p. 594.) Robert Juet, in his account of Hudson's discovery of the river which bears his name, asserts that the savages "had red copper tobacco pipes, and other things of copper, which they did wear about their necks." He makes mention, in another place, of "yellow copper," as distinct from what he terms "red copper." Both Behring and Kotzebue found copper implements in use among the Indians of the Northwest Coast.—(*Behring's First Voy.*, p. 85; *Kotzebue*, *Voy.*, Vol. I., p. 227.) McKenzie mentions copper as being in common use among some of the extreme Northern tribes, on the borders of the Arctic Sea. "They point their arrows and spears with it, and work it up into personal ornaments, such as collars, ear-rings, and bracelets, which they wear on their wrists, arms, and legs. They have it in great abundance, and hold it in high estimation."—(*Second Journey*, p. 333.) Owing to the difficulty of reducing iron from the ore, an acquaintance with that metal has usually been preceded by a knowledge of copper, silver, and gold. "These three metals," says Robertson, "are found in their perfect state in the clefts of rocks, in the sides of mountains, or in the channels of rivers. They were accordingly first known and applied to use. But the gross and stubborn ore of iron, the most serviceable of all metals, and to which man is most indebted, must twice feel the force of fire, and go through two laborious processes, before it becomes fit for use." Says Lucretius:

"*Sed prius* æris *erat*, *quam* ferri *cognitus usus*."

It was the difficulty of obtaining iron from the ores, or the possession of the art of so tempering or hardening copper as to make it answer most of the purposes to which steel is now applied, one or both, that perpetuated the use of bronze instruments in Egypt, as well as in Greece and Rome, long after those nations became acquainted with the former metal.

It may be regarded as certain, that the American aborigines, at the period of the Discovery, were in ignorance of the uses of iron. It is true Vespucius mentions a tribe of natives near the mouth of the La Plata, in South America, who possessed iron points to their arrows. It was probably obtained from native masses in that vicinity. The inhabitants of Madagascar obtain a part of their iron from such sources.* A late traveller in Chile observes: "It appears that the Indians of Chile had, at the time of their discovery, in some very rare instances, iron blades to their lances; which led to the erroneous supposition that they were so far advanced in metallurgy as to be able to reduce and refine that metal from the ores. Our surprise will cease upon recollecting that this valuable metal already existed naturally in South America, in the very extensive deposits of native iron at *Santiago del Estero*, which has proved to be of meteoric origin, and differing from that at Zacatecas and Durango in Mexico, described by Humboldt, in the absence of earthy matter, and in not being, like them, in round masses, but in a horizontal bed of considerable extent and variable thickness, now for the most part covered with drifting sand, and resting on a bed of the same material."—(*Mier's Travels in Chile, etc.*, Vol. II., p. 464.) Copper, on the other hand, seems to have been very abundant, and much used for implements, among all the semi-civilized nations of the continent. Columbus, when at Cape Honduras, was visited by a trading canoe of Indians Amongst the various articles of merchandise which constituted their cargo, were " small hatchets, made of copper, to hew wood, small bells and plates, crucibles to melt copper,

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* *Lieut. H. C. Flagg, Trans. Am. Association, 6th Meeting*, p. 40. It is unnecessary to remark, that all accounts of the discovery of iron in the mounds, or under such circumstances as to imply a date prior to the Discovery, are sufficiently vague and unsatisfactory. The fragment of an iron wedge, found in a rock near Salem, Washington County, Ohio, and which has been alluded to by several writers upon American antiquities, does not probably possess an antiquity of more than fifty years. It is now in the possession of Dr. S. P. Hildreth, of Marietta; and its history, stripped of all that is not well authenticated, is simply that it was found fastened in the cleft of a rock, and no one could tell how it came there! The author of the paper on American antiquities, in the first volume of the Archæologia Americana, states that, in a mound at Circleville, Ohio, was found amongst other articles "a plate of iron which had become an oxyde; but before it was disturbed by the spade, resembled a plate of cast iron. (*Archæol. Am.*, Vol I., p. 178.) It is obviously no easy matter to detect iron when fully oxydized in the earth; and when we are obliged to base our conclusions respecting the use of that metal, by an evidently rude people, upon such remains, if any there be, the strictest examination should be given them; appearances alone should be disregarded, and conclusions, after all, drawn with extreme caution. Whether it is likely the requisite discrimination and judgment were exercised in this case, it is not undertaken to say. But few masses of native iron, and these of small size and meteoric origin, have been found in this country; consequently the presence of iron to any extent amongst the mound-builders, can be accounted for only on the assumption that they understood the difficult art of reducing it from the ores, which involves a degree of knowledge, and an advance in the arts of civilization, not attained by the Mexicans nor by the Peruvians, and not sustained by the authenticated remains of the mounds.

etc."—(*Herrara*, Vol. I., p. 260.) When the Spaniards first entered the province of Tuspan, they found the Indians in possession of an abundance of copper axes, which, in their greediness, they mistook for gold, and were much mortified upon discovering their mistake. "Each Indian," says Bernal Diaz, "had, besides his ornaments of gold, a copper axe, which was very highly polished, with the handle curiously carved, as if to serve equally for an ornament as for the field of battle. We first thought these axes were made of an inferior kind of gold; we therefore commenced taking them in exchange, and in the space of two days had collected more than six hundred; with which we were no less rejoiced, as long as we were ignorant of their real value, than the Indians with our glass beads." In the list of articles exacted as an annual tribute from the various departments of the Mexican empire, as represented by the Mexican paintings, were "one hundred and sixty axes of copper" from the southern divisions.

Fig. 54.

Fig. 54 is copied from the tribute tables, and illustrates the form of the axes required to be paid to the emperor. This seems to have been the usual form, which, however, was sometimes slightly modified, so as to give them a broader cutting edge. The following example, Figs. 55 and 56, are drawings of originals obtained by Du Paix, and published among the plates of his antiquarian tour. They are engraved of one fourth their actual size.

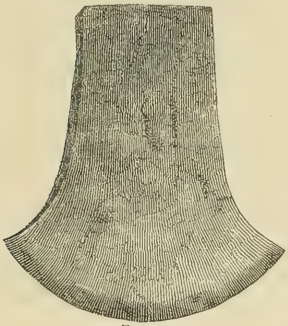


Fig. 55.

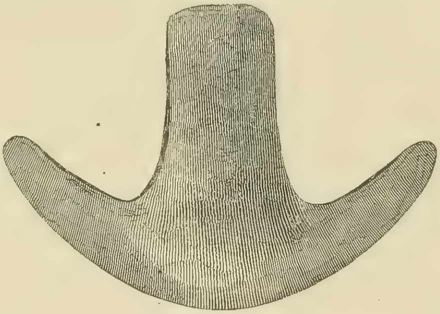


Fig. 56.

They were part of a deposit of two hundred and seventy-six, of like character, found buried in two large earthen vases, in the vicinity of Oxaca, and are of alloyed copper, and cast. "Such," says Du Paix, "are much sought by the silversmiths, on account of their fine alloy."

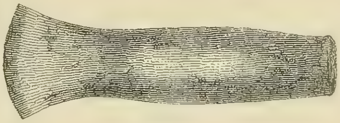


Fig. 57.

Fig. 57 is a chisel, of similar composition, found in the vicinity of Mexico, and also figured by Du Paix. It is engraved *one fourth* of the original size.

The methods in which these axes were used are well shown in the subjoined cuts, faithfully copied from the Mexican paintings, Figs. 58 and 59. They require

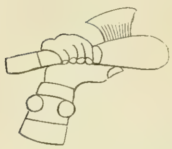


Fig. 58.

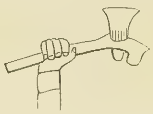


Fig. 59.

Fig. 60.

no explanation beyond what is furnished by Clavigero, who says: "The Mexicans made use of an axe to cut trees, which was also made of copper, and was of the same form as those of modern times, except that we put the handle in an eye of the axe, while they put the axe in an eye of the handle." Fig. 60 is copied from the Mendoza Paintings, and represents a carpenter using one of these axes, or one very similar, adjusted, probably, so as to answer the purpose of an adze.

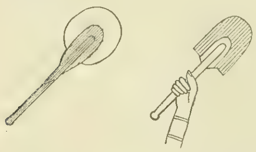


Fig. 61.

In the Mexican battle paintings, we occasionally observe weapons, the blades of which were of copper, as is shown by their green color, and which were used something after the manner of the battle-axe. Examples are here given, Fig. 81.

But although copper was used for such purposes, it does not appear that it entirely substituted itself for stone; for stone axes, and weapons formed by inserting blades of obsidian or *itzli* in solid pieces of wood, were common as late as the period of the Spanish conquest. The instrument this formed was called *mahquahuitl*, and was much dreaded by the Spaniards, who told wonderful stories of their efficiency, affirming that a single stroke was sufficient to cut a man through the middle, or decapitate

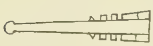


Fig. 62.

Fig. 63.

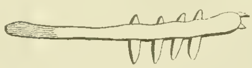


Fig. 64.

a horse. Figs. 62 and 63 are examples from the paintings, and Fig. 64 is copied from the monuments at Chichen Itza, in Yucatan. The latter represents an axe, or rather, weapon of war, made by inserting blades of obsidian in a handle of wood, as above described. It will be seen by reference to Vol. I., p. 211, of these Contributions, that there is reason to believe that an entirely corresponding practice prevailed amongst the mound-builders. The device is an extremely simple one, and seems to have been common to many rude nations.

The copper axes of ancient Egypt closely resembled those above described, both in form and the mode of attachment to the handle. The accompanying illustration, Fig. 65, reduced from one of Visconti's plates, represents one of unique

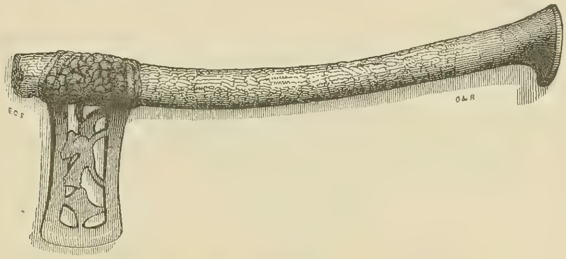


Fig. 65.

and ornamental workmanship. It will be observed that it is also lashed to the handle with thongs: differing from the primitive American axe, only in the manner of insertion. In this instance the broad end of the tool is sunk in the wood.

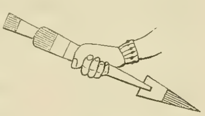


Fig 66.

The Mexicans also used copper to point their spears and arrows; although here obsidian was often substituted. Fig. 66 is a representation of a short javelin, which we find of frequent occurrence in the paintings, and which seems to have been used only in close combat. The long javelin, or that which was thrown from the hand, is well shown in Fig. 67, which exhibits the

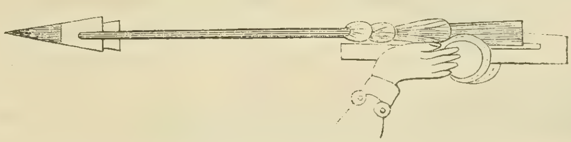


Fig. 67.

manner in which it was thrown, and also the *xuiatlatli*, or instrument used in throwing it, and by means of which it was sent with greater accuracy and force than could otherwise be attained. The gods are almost always represented, in the mythological paintings, holding the *xuiatlatli* in their hands. It is often fancifully ornamented with tassels and feathers.

The Peruvians used copper for precisely the same purposes with the Mexicans. Says La Vega, "They make their arms, knives, carpenters' tools, large pins, hammers for their forges, and their mattocks, of copper; for which reason they seek it in preference to gold." And Ulloa adds, "The copper axes of the Peruvians differ very little in shape from ours; and it appears that these were the implements with which they performed most of their works. They are of various shapes and

sizes; the edge of some is more circular than others, and some have a concave edge."—(Vol. I., p. 483.)

The knowledge of alloying was possessed by both the Mexicans and Peruvians, whereby they were enabled to make instruments of copper of sufficient hardness to answer the purposes for which steel is now deemed essential. Their works in stone and wood, whether in dressing the huge blocks of porphyry composing some of their structures, or in sculpturing the unique statues which are found scattered over the seats of their ancient cities, were carried on entirely with such instruments, or with still ruder ones of obsidian and other hard stones.

The metal used as an alloy was tin; and the various Peruvian articles subjected to an analysis, are found to contain from three to six per cent. of that metal. The chisel analyzed by Humboldt contained copper 94, tin 6.—(*Res.*, Vol. I., p. 260.)

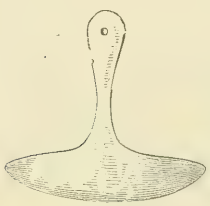


Fig. 68.

Figure 68 is a reduced sketch of a copper knife found in Peru, by J. H. Blake, Esq., of Boston. It has about four per cent. of tin. This gentleman informs me, that "The knives, gravers, and other implements found by myself in Peru, contain from three and a half to four per cent. of tin, which is sufficient to give them a very considerable degree of hardness.* The knives which I send you were found about the person of a mummy which I took from an ancient cemetery near Arico. Various household articles were found with it; but these were the only ones of metal, except a medal of silver suspended around the neck. The chisels or gravers are pointed at one end, with a cutting edge at the broad part. They were found at various places in the northern part of Peru. At the ancient city of Atacama, I found several hoes of copper, shaped very much like the 'grubbing-hoes' to be found in our warehouses."

Figure 69 is a reduced sketch of an ancient Peruvian spear-head, of copper,

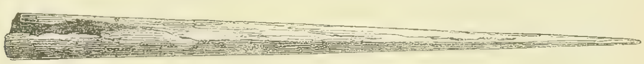


Fig. 69.

found in a Peruvian *huaca* or tumulus, near Lima, whence it was brought by the late Dr. Marmaduke Burroughs, in 1826, and by him presented to Dr. S. G. Morton, of Philadelphia, in whose possession it now is. It is somewhat flattened, and regularly four-sided from the point to within a third of the distance from the larger end, where it becomes cylindrical. This part is hollow, for the reception of the handle. The metal is not hardened, and is now covered with a green oxyde. The

* The Indians of Chile, previous to the discovery by the Spaniards, made use of a kind of *bronze metal*, found native in the country, which is an alloy of copper, zinc, and antimony, called *campañil* by the Spaniards. From this they formed their cutting instruments.—(*Mier's Trav.*, Vol. II., p. 464.)

length of the weapon is seventeen inches, and the diameter, at the larger end, one inch and one-tenth.

Figure 70 is a full-size engraving of one of the arrow-points discovered with a skeleton, near Fall River, Massachusetts, in the year 1831. With this skeleton were found a corroded plate of brass, supposed to have constituted a breastplate.

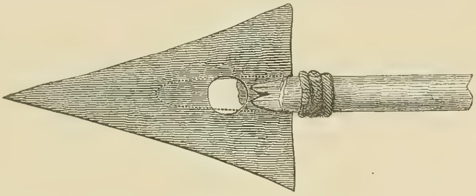


Fig. 70.

and a number of rude tubes of the same metal, composing a sort of belt or cincture. The arrow-points are two inches in length, and one and one-third inches broad at the base. This skeleton attracted a good deal of attention at the time, and was supposed to lend some sanction to the then popular theory of the early discovery and settlement of the coast of New England by the Northmen. An analysis of the compound metal of which the relics were composed, was made by Berzelius, under the direction of the Royal Society of Antiquaries of Denmark. The result of the analysis was published by that learned body, in the following comparative table:

	Copper.	Zinc.	Tin.	Lead.	Iron.
Brass from Fall River, . . .	70.29	28.03	0.91	0.74	0.03
Old Danish, ...	67.13	20.39	9.24	3.39	0.11
Modern Brass, ...	70.16	27.45	0.79	0.20	——

It will be seen by the table, that the metallic relics found at Fall River bear in their composition a suspicious resemblance to modern brass. They certainly differ widely, in this respect, from any of the alloys of copper found elsewhere on the continent. Without alluding to the rudeness of the workmanship exhibited by the Fall River relics,—a rudeness entirely inconsistent with that stage of advancement indicated by a knowledge of smelting and alloying the metals,—the fact that the skeleton accompanying them was found buried, after the Indian mode, in a sitting posture, and enveloped in bark, places in a very strong light the probability that the burial was made subsequent to the first settlement of New England, in 1625, and that the relics were of native manufacture, from sheets or plates of brass obtained from the early colonists. This probability is further sustained, by the circumstance that a portion of the wood attached to the arrows was still preserved, as was also a large proportion of the bark envelope of the skeleton, at the time of its discovery; which could hardly be the case, if its interment had been made as early as the tenth century, which is the period assigned to the Scandinavian visits. It cannot be claimed that the preservative properties of the salts of the copper could have more than a very local application or influence.

And while upon this point, it may be mentioned that Wood, in his "New England

Prospect," published in 1634, (p. 90,) distinctly states that the Indians obtained brass of the English for their ornaments and arrow-heads, the last of which, he adds, "*they cut in the shape of a heart and triangle, and fastened in a slender piece of wood, six or eight inches long*"—in a manner, according to the description, precisely similar to that observed in the articles found with the Fall River skeleton. If any further evidence were needed to establish the opinions already advanced, it might be found in the fact that, a few years ago, in the town of Medford, near Boston, in Massachusetts, a skeleton was exhumed, accompanying which were found some flint arrow-heads, and some brass arrow-points, *identical* with those discovered at Fall River, together with a *knife of the English manufacture* of two hundred years ago. Fig. 71 is a full-sized engraving of the arrow-point in question, which is now in the possession of the author.

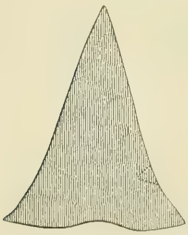


FIG 71.

It has already been suggested that the shore of Lake Superior is the probable locality whence the copper used by the aborigines of, at least, the Eastern and Middle States was obtained. This suggestion is rendered more than probable by the fact that abundant traces of aboriginal mining have been discovered there in the course of recent explorations. Some of the more productive veins in the "Copper Region" seem to have been anciently worked to a considerable extent. The vein belonging to the "Minnesota Company" exhibits evidence of having been worked for a distance of two miles. The ancient operations are indicated by depressions or open cuts on the course of the vein. Upon excavating these, ample proofs of their artificial origin are discovered, consisting of broken implements of various kinds, stone axes, hammers, etc. Traces of fire are also frequent. Some of the excavations are found to have extended to the depth of thirty feet. In the mine of the particular company above named, covered by fifteen feet of accumulated soil, and beneath trees not less than four hundred years old, was found a mass of pure copper, weighing 11,537 lbs., from which every particle of the rock had been removed. It had been supported by *skids*, and was surrounded by traces of the fire which had probably been used to disengage the rock. Here, too, were found various rude implements of copper.

At the Copper Falls and Eagle River, as at the Vulcan and other mines, the ancient shafts are frequently discovered. Professor W. W. Mather, the eminent geologist, in a private letter, referring to the two mines first named, says: "On a hill, south of the Copper Falls Mine, is an excavation, several feet in depth and several rods in length, extending along the course of the river. Fragments of rock, etc., thrown out of the excavation, are piled up along its sides, the whole covered with soil, and overgrown with bushes and trees. On removing the accumulations from the excavation, stone axes of large size, made of green-stone, and shaped to receive withe handles, are found. Some large round green-stone masses, that had apparently been used for sledges, were also found. They had round holes bored in them to the depth of several inches, which seemed to have been designed for wooden plugs, to which withe handles might be attached, so that several men could swing them with sufficient force to break the rock and the projecting masses of

copper. Some of them were broken, and some of the projecting ends of rock exhibited marks of having been battered in the manner here suggested."

The great Ontonagon mass of virgin copper, now deposited at Washington, when found, exhibited marks of having had considerable portions cut from it; and the ground around it was strewed with fragments of stone axes, which had been broken in endeavors to detach portions of the mass. It is not impossible that this mass was one of those which had been brought to the surface by the ancient miners.*

The questions naturally arise, By whom were these ancient mining operations carried on? and to what era may they be referred? Without noticing the improbable suggestion, that the various excavations which have been discovered are due to the French, (who, it is well known, were early acquainted with the mineral riches of the Northwest,) we may find a satisfactory answer to the first of these questions, if not to the last, in the character of the deposits which recent explorations have disclosed from the mounds of the West. Among the multitude of relics of art found buried upon the ancient altars, or beside the bones of the dead, articles of copper are of common occurrence. It is sometimes found in native masses, but generally worked into articles of use or ornament. I have taken from the mounds axes, well wrought from single pieces, weighing upwards of two pounds each. They are symmetrical, corresponding very nearly in shape with the Mexican and Peruvian axes. Some are double-bladed, others *gouge-shaped*, and evidently designed to be used as adzes. Beside these, chisels, graving tools, and a great variety of ornaments, bracelets, gorgets, beads, etc., etc., composed of this metal, have been discovered. Some of the ornaments are covered with silver, beaten to great thinness, and so closely *wrapped around* the copper that many persons have supposed that the ancient people understood the difficult art of plating.

Some years ago, a mass of native copper, weighing upwards of twenty pounds, was found upon the banks of the Scioto River, near Chilicothe, in Ohio. Large portions had evidently been cut from it. The discovery of these native masses, not to mention the amount of the manufactured copper, implying a large original supply, points pretty certainly to the shores of Lake Superior as the locality whence the

* Since the above was written, the subjoined additional facts have been published in the Lake Superior Journal newspaper, of the date of September 25, 1850:

"We have been shown by Charles Whittlesey, Esq., of the Ontonagon Mine, a copper arrow-head, and a piece of human skull and other bones, which have lately been found in the ancient Indian excavations on the Ontonagon River. The arrow-head is now about two inches in length, and seems to have had originally a socket, though but part of it remains. Several chisels, or instruments resembling chisels, having sockets like the common carpenter's chisel, and small gads or wedges, have also been found at the Minnesota Mine.

"But the greatest curiosity we have seen in the way of these articles is a stick of oak timber lately taken out of one of the ancient 'pits,' or shafts, at the Minnesota Mine, twenty-seven feet below the surface. It is a small tree, about ten feet in length, and eight or ten inches in diameter, having short limbs two feet apart, and at nearly right angles with one another; and on this account, and from its standing nearly upright, it is supposed to have been used as a ladder by the ancient miners. In this shaft, and around and over this stick, were rocks and earth, and large trees were growing over it. Many centuries must have elapsed since that ancient ladder was placed there."

metal was obtained. There are other circumstances, still more conclusive, and which, taken in connection with the traces of ancient mining in the mineral region, leave no room to doubt that the race of the mounds obtained their supplies of copper from that direction. It is well known that while some of the Lake Superior copper is almost perfectly pure, a part is alloyed with silver in various proportions, and some is found having crystals of silver attached to it,—a peculiar *mechanico-chemical combination*, known to exist nowhere except in this region. This characteristic combination has been observed in some of the specimens, both worked and unworked, found in the mounds, and enables us to identify fully their primitive locality. The great industry and skill which the mound-builders displayed in the numerous and often gigantic monuments which they have left us at the West, warrant us in ascribing the ancient excavations, etc., in the mineral region to them. The Indian hunter is proverbially averse to labor; and we have no instance of the Indians undertaking works of this extent. Still, it cannot be doubted that they also obtained copper from this region. Indeed, we have direct evidence of the fact; but it is probable that they procured it only in small quantities, when it was found exposed at the surface, or on the banks of streams. Alexander Henry, who penetrated to Lake Superior at the period of the second French war, assures us that the Indians obtained copper here, which they "made into bracelets, spoons," etc.—(*Travels*, p. 195.) As we have seen, the early explorers on the coasts of New England, New York, Virginia, the Carolinas, and Florida, among whom we may mention Hudson, Verrazano, Raleigh, Heriot, Ribaude, De Soto, all concur in saying that the Indians had copper in small quantities among them, which they worked into pipes and ornaments. De Soto found copper hatchets among some of the tribes along the Gulf, which they professed to have obtained from "a province called *Chisca*, far toward the North."

All the copper found in the mounds appears to have been worked in a cold state; and although the axes and other instruments appear to be harder than the copper of commerce, they have been found, upon analysis, to be destitute of alloy. The superior hardness which they possess over the unworked metal, is doubtless due to the *hammering* to which they have been subjected. Some of the sculptures in porphyry, and other hard stones found in the mounds, exhibit traces of having been *cut;* but as they now turn the edge of the best tempered knife, we are at a loss to conjecture how they were so elaborately and delicately worked. The lack of cutting implements, among most rude people, is partially met by various contrivances, the most common of which is attrition, or rubbing or grinding on hard stones. It was thus the stone axes, etc., of the early Indians were slowly and laboriously brought into shape. It however needs but a single glance at the mound sculptures to convince the observer that such rude means are wholly inadequate to the production of works possessing so much delicacy of execution.

The Mexicans and Peruvians were wholly unacquainted with the use of iron; and their carvings, etc., were all wrought with copper tools. They, however, contrived to harden them with an alloy of from three to seven per cent. of tin. I have some of their implements in my possession, which answer a very good cutting purpose. It nevertheless seems incomprehensible how their extensive works in granite, por-

phyry, and other obstinate materials, could be carried on with such aids. The Egyptians, although not ignorant of iron, were compelled, by a variety of circumstances, to use copper tools, and with these most of their gigantic labors were effected. They must of necessity have had some means of hardening the metals; yet it is a singular fact, that, with the exception of a few bronze weapons of probably a comparatively late date, the chisels and other implements found in the monuments and at the quarries are *pure copper.*

Use of Silver by the American Aborigines.—Granville, as we have seen in the quotation from his voyage on page 177, speaks of finding pieces of silver amongst the Virginia Indians, "grossly beaten," and used for purposes of ornament. Having shown that the copper found amongst the Indian tribes of the north was probably obtained from the native deposits around Lake Superior, we have little difficulty in accounting for the presence among them of small quantities of silver, derived from the same locality, where it also exists in a native form. That the silver in use amongst the mound-builders was principally if not wholly obtained there, seems incontestible. In no instance does it appear to have been smelted.

A variety of silver ornaments were discovered some years ago in one of the mounds at Marietta, Ohio, under very singular circumstances, and in a remarkable connection. The circumstances have been detailed by the accurate pen of Dr. S. P. Hildreth, in a communication to the President of the American Antiquarian Society, dated "Marietta, Nov. 3, 1819."

"In removing the earth composing an ancient mound in the streets of Marietta, on the margin of the plain, near the fortifications, several curious articles were discovered. They appear to have been buried with the body of the person to whose memory the mound was erected.

"Lying immediately over, or on the forehead of the body, were found three large circular bosses, or ornaments for a sword-belt or a buckler: they are composed of copper overlaid with a thick plate of silver. The fronts are slightly convex, with a depression like a cup in the centre, and measure two inches and a quarter across the face of each. On the back side, opposite the depressed portion, is a copper rivet or nail, around which are two separate plates, by which they were fastened to the leather. Two small pieces of the leather were found lying between the plates of one of these bosses; they resemble the skin of a mummy, and seem to have been preserved by the salts of copper. The copper plates are nearly reduced to an oxyde, or rust. The silver looks quite black, but is not much corroded, and in rubbing is quite brilliant. Two of these are yet entire; the third one is so much wasted that it dropped in pieces in removing it from the earth. Around the rivets of one of them is a small quantity of flax or hemp, in a tolerable state of preservation. Near the side of the body was found a plate of silver, which appears to have been the upper part of a sword-scabbard; it is six inches in length and two inches in breadth, and weighs one ounce. It has no ornaments or figures, but has three longitudinal ridges, which probably corresponded with the edges or ridges of the sword; it seems to have been fastened to the scabbard by three or four rivets, the holes of which remain in the silver.

"Two or three broken pieces of a copper tube were also found, *filled with iron rust.* These pieces, from their appearance, composed the lower end of the scabbard, near the point of the sword. No signs of the sword itself were discovered, except the appearance of rust above mentioned. Near the feet was found a piece of copper weighing three ounces [now in the Museum of the Antiquarian Society of Worcester]. From its shape it appears to have been used as a *plumb*, or for an ornament, as near one of the ends is a circular crease or groove, for tying a thread: it is round, two inches and a half in length, one inch in diameter at the centre, and half an inch at each end. It is composed of small pieces of native copper pounded together; and in the cracks between the pieces are stuck several pieces of silver, one nearly the size of a half-dime. A piece of red ochre or paint, and a piece of iron ore [*hematite*] which had the appearance of having been partially vitrified [*polished?*], were also found.

"The body of the person here buried was laid upon the surface of the ground, with his face upwards, and his feet pointing to the southwest. From the appearance of several pieces of charcoal and bits of partially burned fossil coal, and the black color of the earth, it would seem that the funeral obsequies had been celebrated by fire; and while the ashes were yet hot and smoking, a circle of these flat stones had been laid around and over the body. The circular covering was about eight feet in diameter; and the stones yet look black, as if stained by fire and smoke. This circle of stones seems to have been the nucleus over which the mound was formed, as immediately over them is heaped the common earth of the adjacent plain. At the time of openingt i, the height was 6 feet, and diameter between 30 and 40. It has every appearance of being as old as any in the neighborhood, and was, at the first settlement of Marietta, covered with large trees. It seems to have been made for this single personage, as the remains of one skeleton only were discovered. The bones were much decayed, and many of them cumbled to dust on exposure to the air."

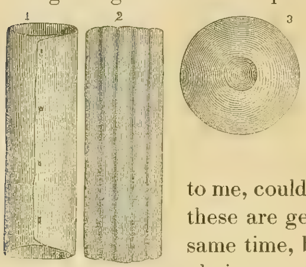


Fig. 72.

Engravings of the silver-plated discs and also of the embossed silver plate supposed by Dr. Hildreth to have been a sword ornament, are herewith presented. These articles have been critically examined, and it is beyond doubt that the copper "bosses" are absolutely *plated*, not simply overlaid, *with silver*. Between the copper and the silver exists a connection, such as, it seems to me, could only be produced by heat; and if it is admitted that these are genuine remains of the mound-builders, it must, at the same time, be admitted that they possessed the difficult art of plating one metal upon another. There is but one alternative, viz., that they had occasional or constant intercourse with a people advanced in the arts, from whom these articles were obtained. Again, if Dr. Hildreth is not mistaken, *oxydized iron*, or steel, was also discovered in connection with the above remains; from which also follows, as a necessity upon the previous assumption, the extraordinary conclusion that the *mound-builders were acquainted with the use of iron*,—the conclusion being, of course, subject to the improbable alternative already mentioned.

Leading, therefore, as they do, to such extraordinary conclusions, it is of the utmost importance that every fact and circumstance connected with these remains should be narrowly examined. If there is a reasonable way of accounting for their presence, under the circumstances above described, without involving us in these conclusions, unsustained as they are by collateral facts, we are justified upon every recognised rule of evidence in adopting it as the nearest approximation to the truth.

The existing tribes of Indians, it has been demonstrated, recently and remotely, often buried in the mounds, placing the arms and ornaments, in short, whatever was valued by the possessor while living, in the grave with him at his death. It has been shown that in some instances they opened the mounds to the depth of six or seven feet, and buried at or below their bases.—(*Ancient Monuments of the Mississippi Valley*, pp. 146, 147, 149.) It has been shown, also, that partial burial by fire was occasionally practised by them, or by races succeeding the builders of the mounds. That it was a common custom among the Indians to cover their dead with stones, is also well known. The occurence of these remains in the position above described, does not, therefore, necessarily establish that they belonged to the race of the mounds.

I.

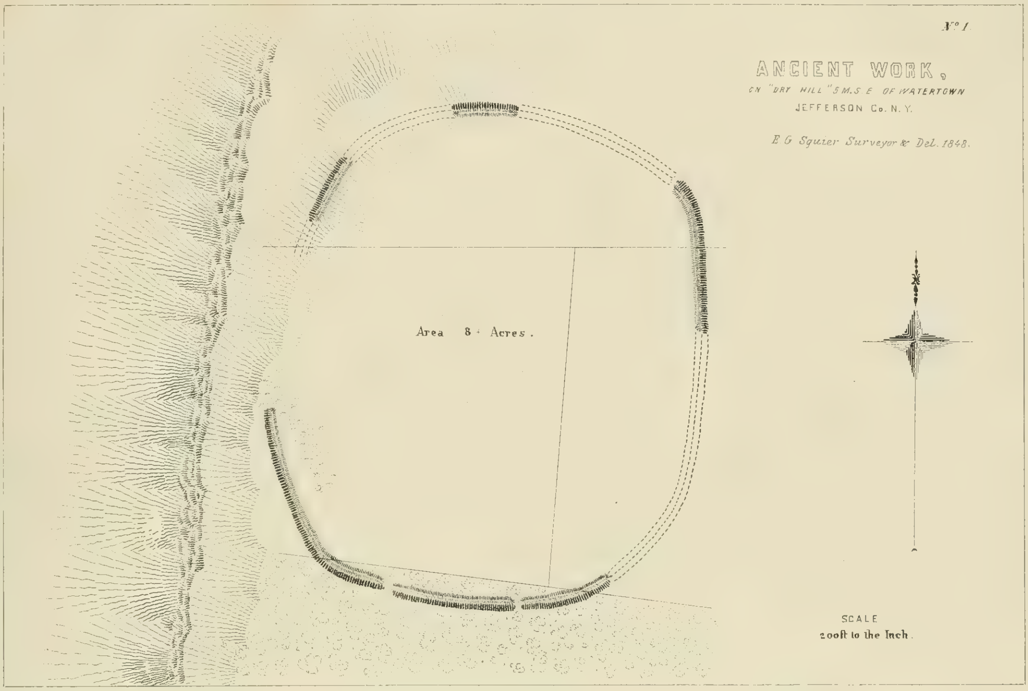
ANCIENT WORK,

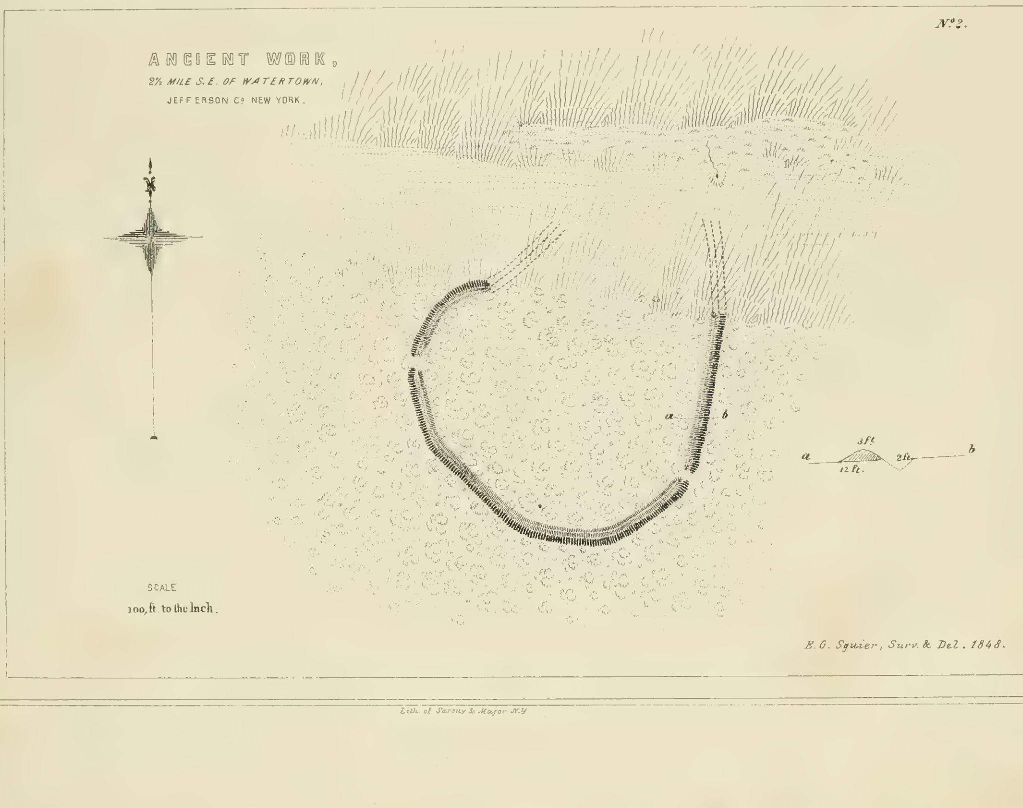
N. E. PART OF ADAMS TP. JEFFERSON COUNTY.

7 Miles S. E. of Watertown.

E. G. Squier Surveyor and del. 1848.

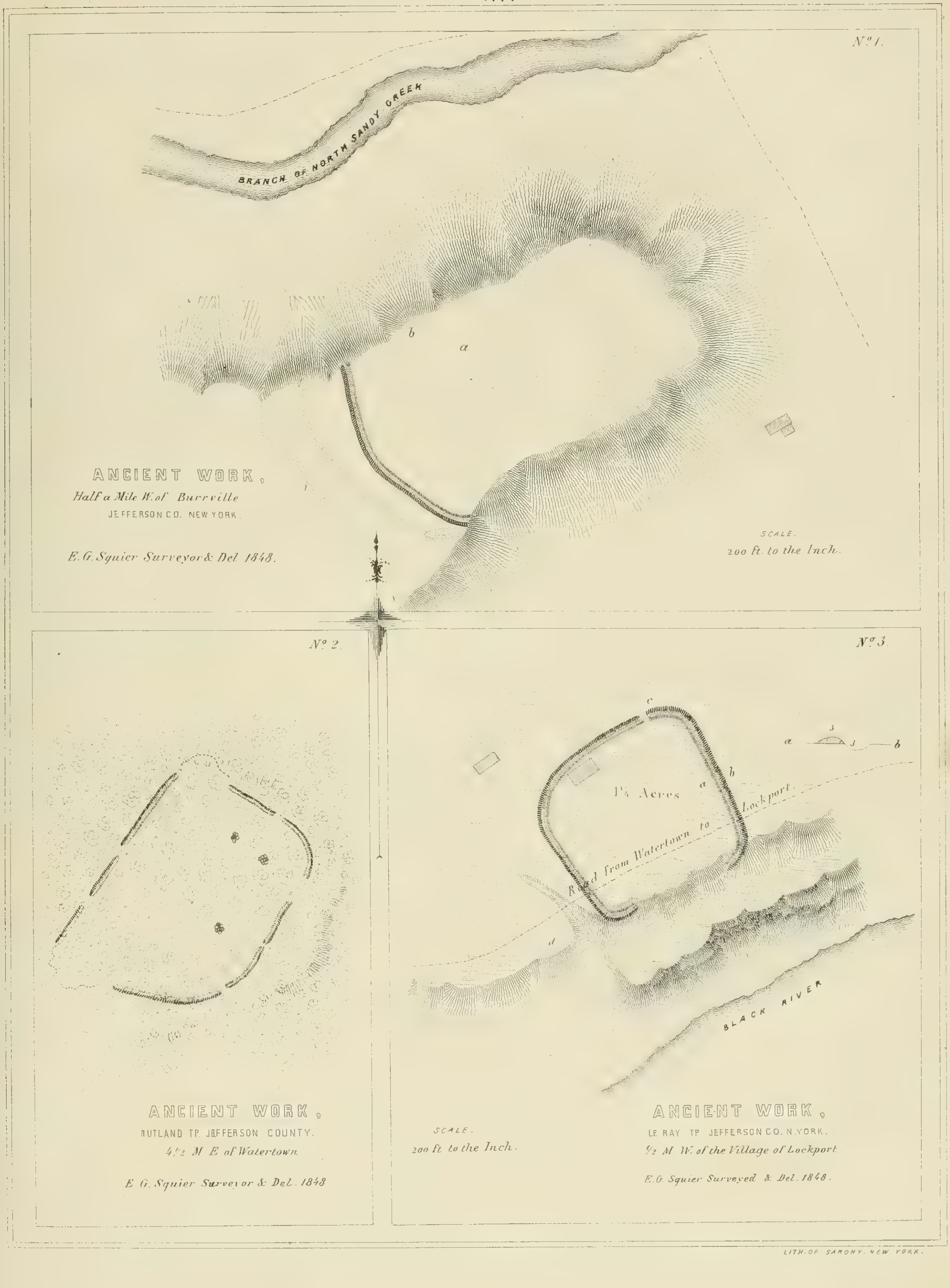
SCALE,
200 ft. to the Inch.



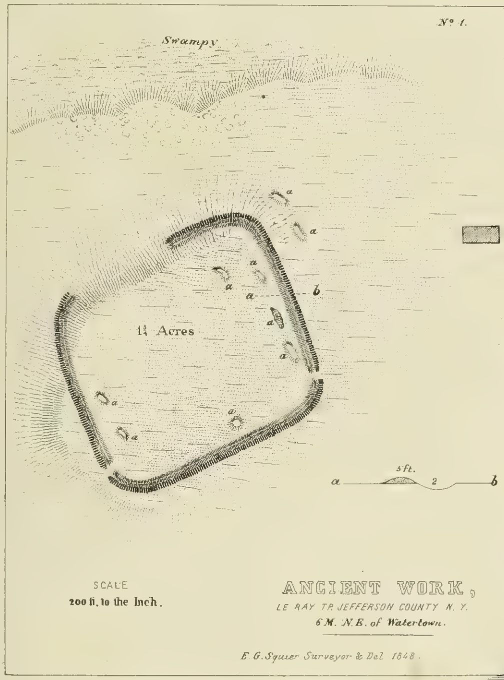


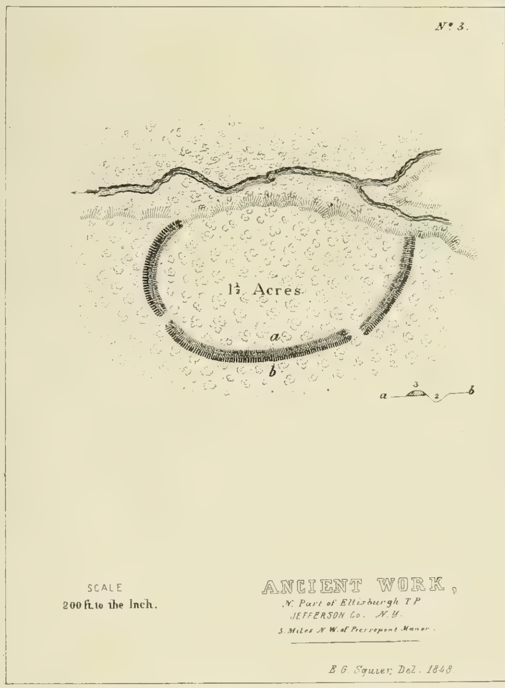
Lith. of Sarony & Major N.Y.

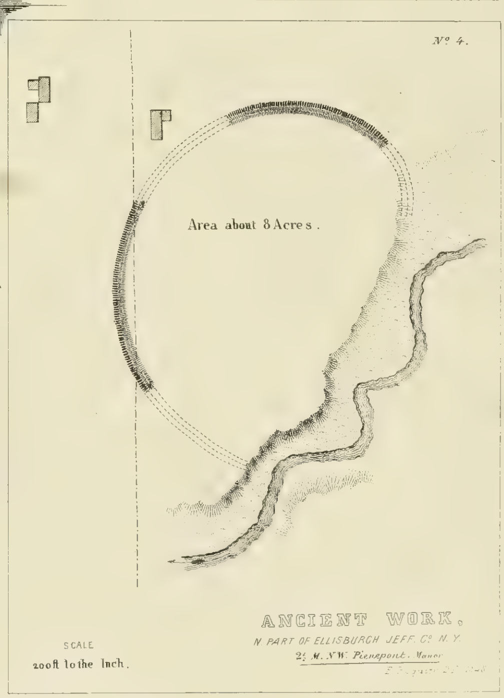
III.



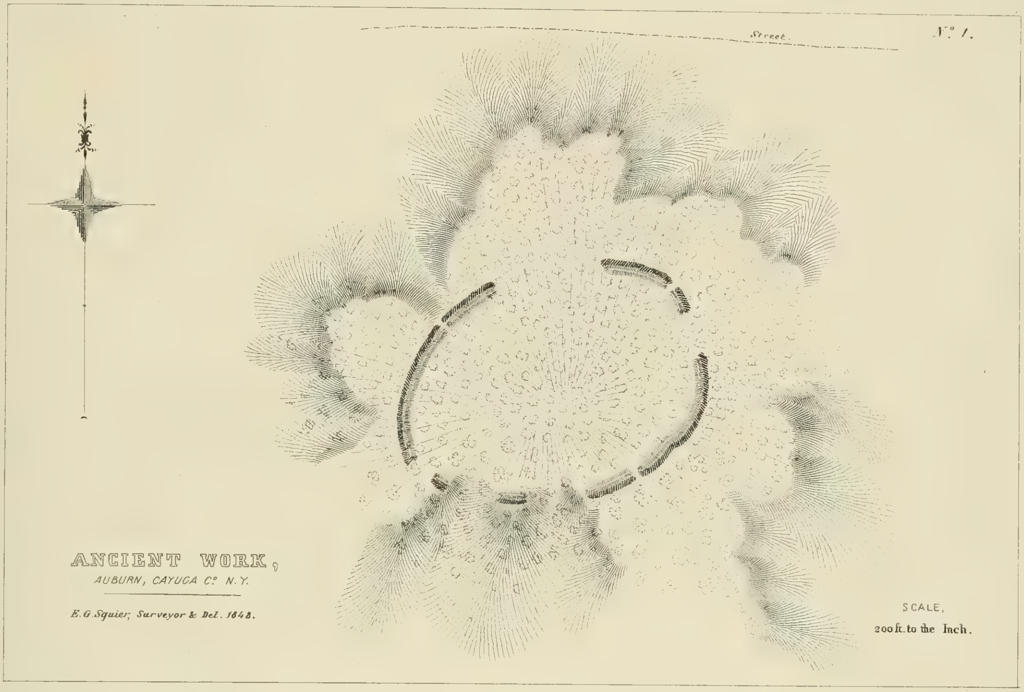
LITH. OF SARONY, NEW YORK.

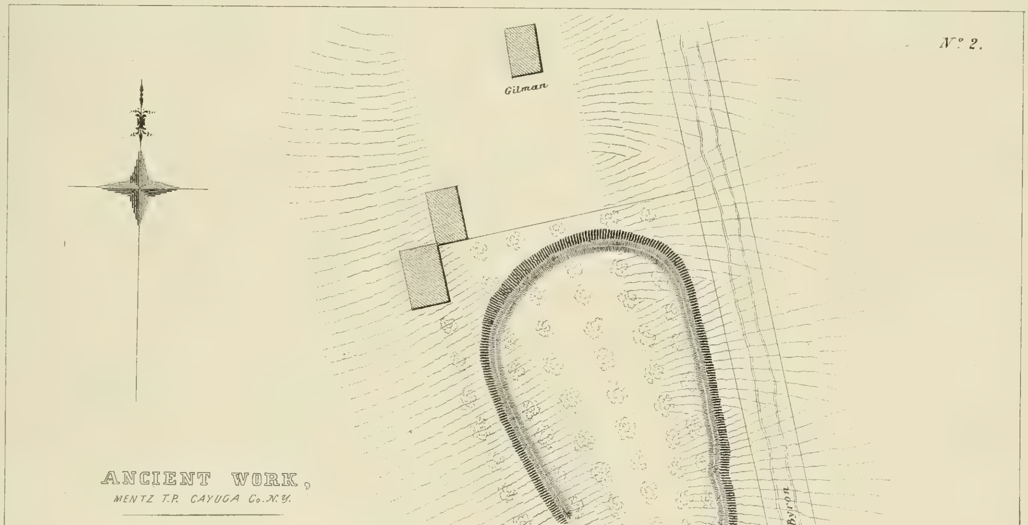






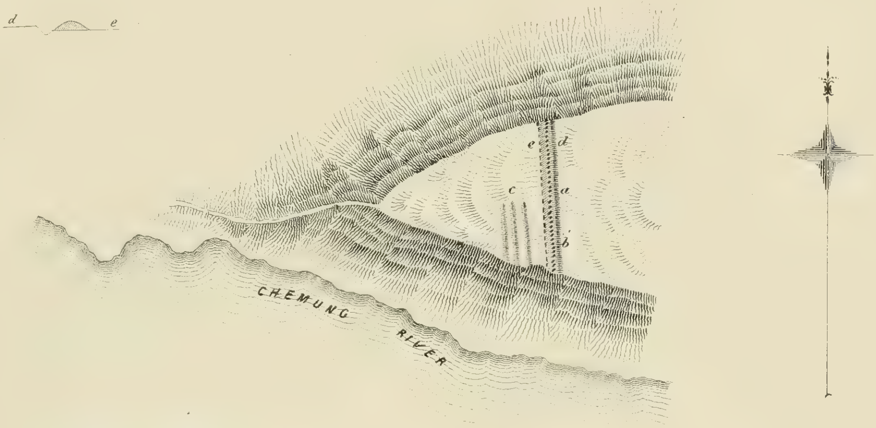
Lith. of Sarony & Major N.Y.





Lith. of Sarony & Major N. Y.

No. 1.



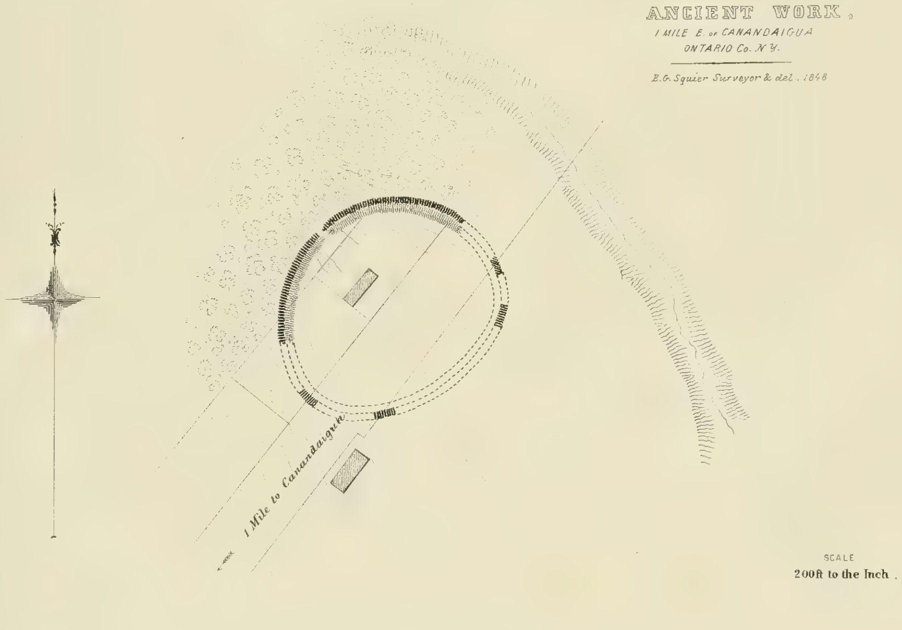
ANCIENT WORK,
NEAR ELMIRA, CHEMUNG Co. N.Y.

E. N. Horsford, del. 1838.

No. 2

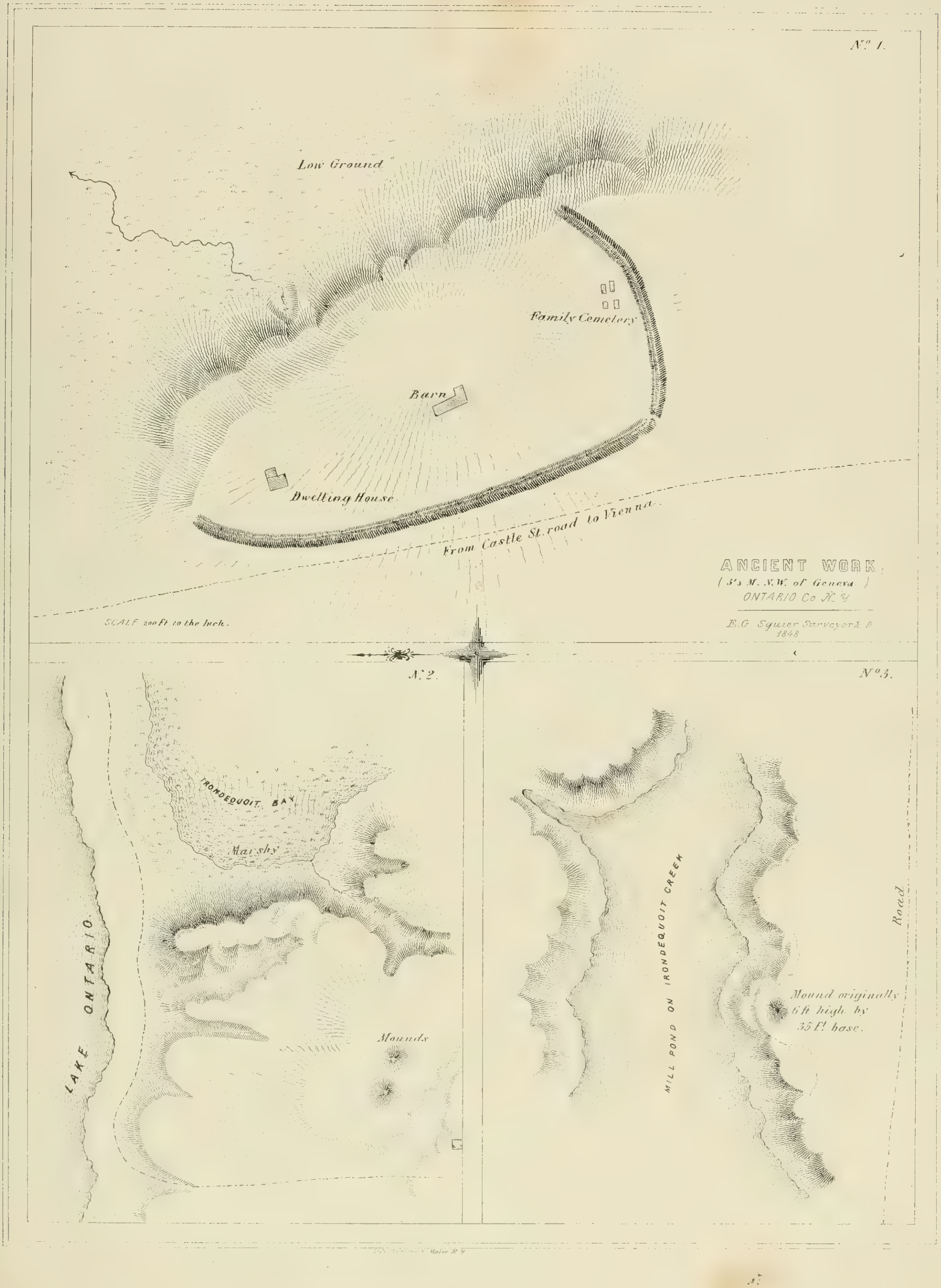
ANCIENT WORK,
1 MILE E. of CANANDAIGUA
ONTARIO Co. N.Y.

E. G. Squier Surveyor & del. 1848



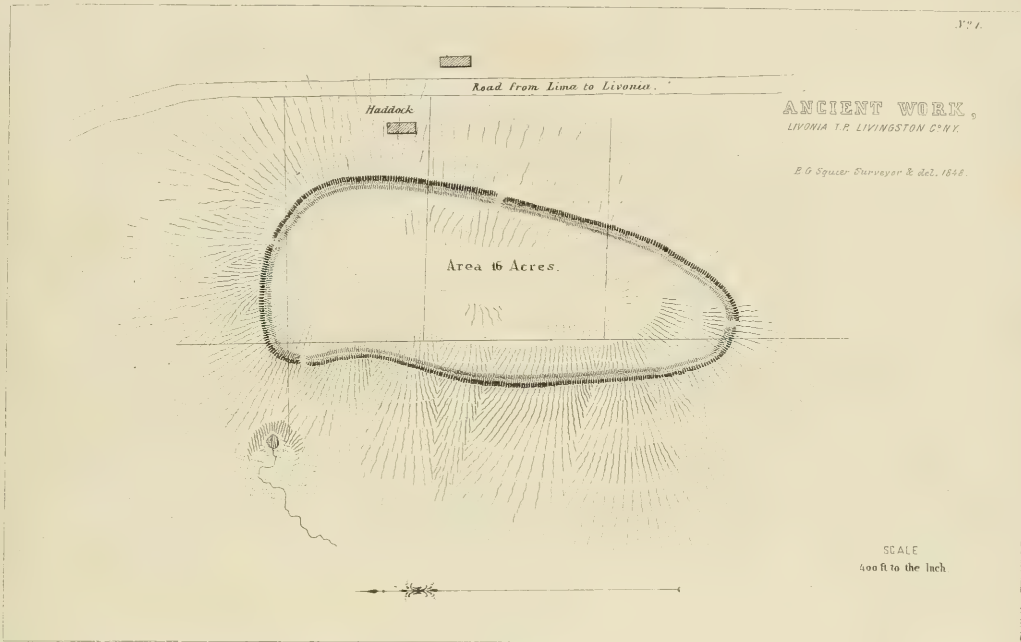
Lith. of Sarony & Major N.Y.

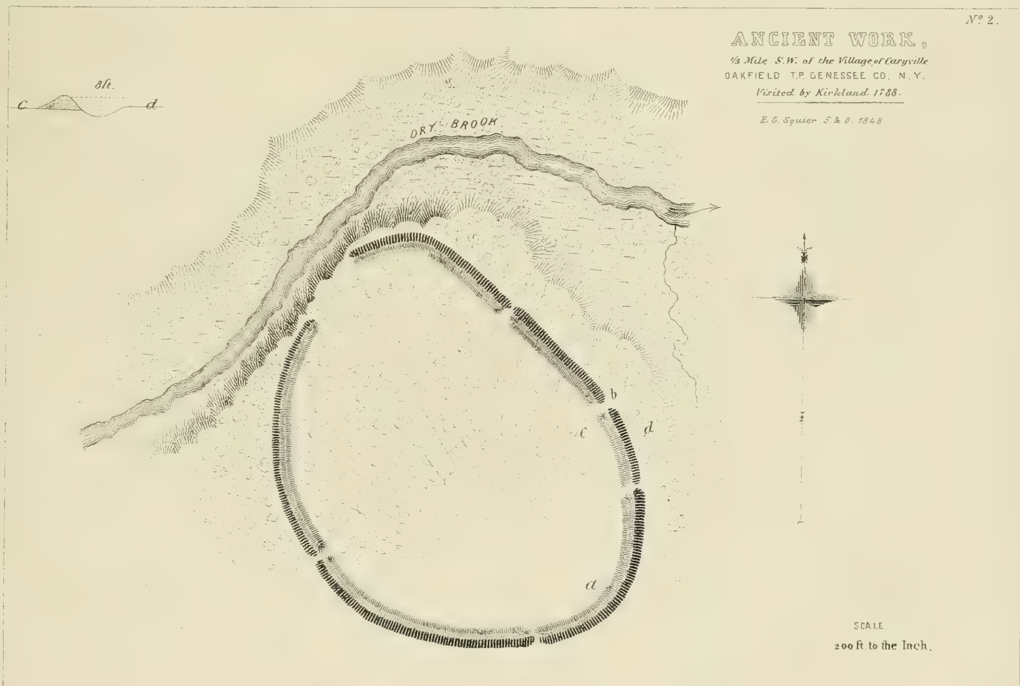
VII.



Nº 1.
Low Ground
Family Cemetery
Barn
Dwelling House
From Castle St. road to Vienna.
ANCIENT WORK.
(3½ M. N.W. of Geneva.)
ONTARIO Co N.Y.
E.G. Squier Surveyor & D.
1848
SCALE 200 Ft. to the Inch.
Nº 2.
IRONDEQUOIT BAY
Marshy
LAKE ONTARIO.
Mounds
Nº 3.
MILL POND ON IRONDEQUOIT CREEK
Road
Mound originally
6 ft. high by
35 Ft. base.

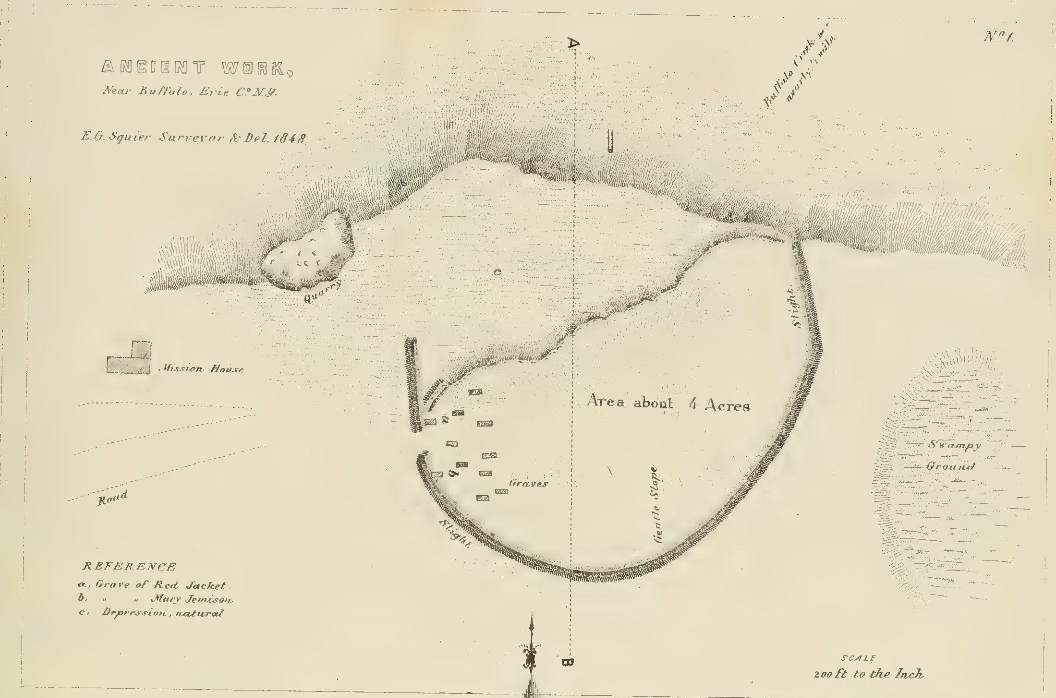
VIII.

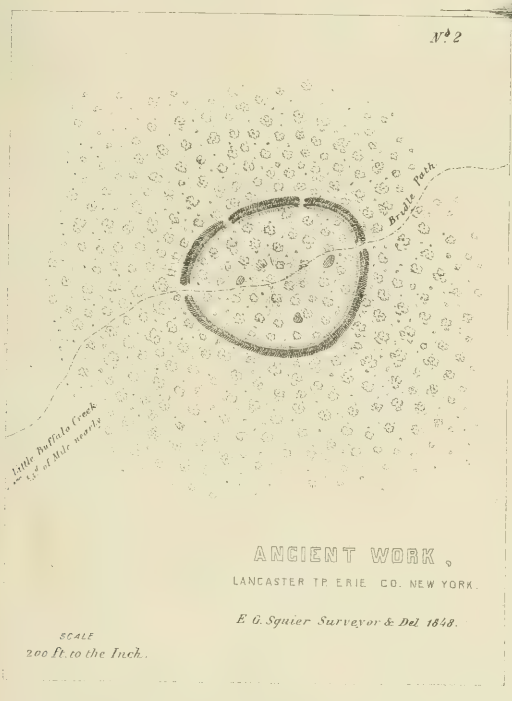


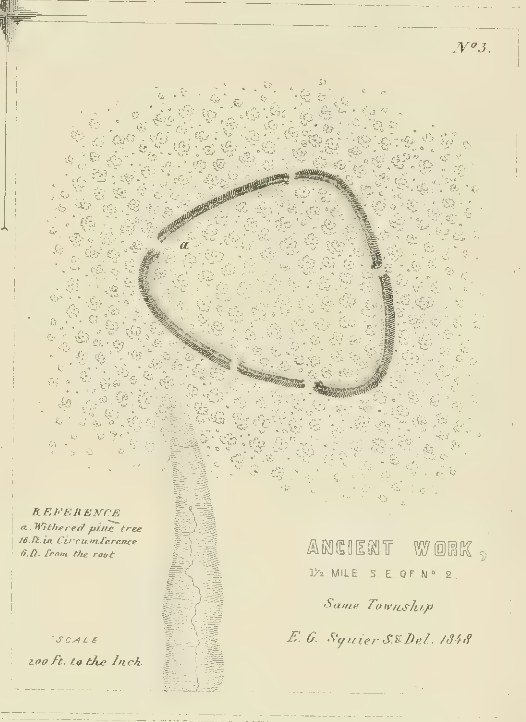


Lith. of Sarony & Major, N.Y.

IX.

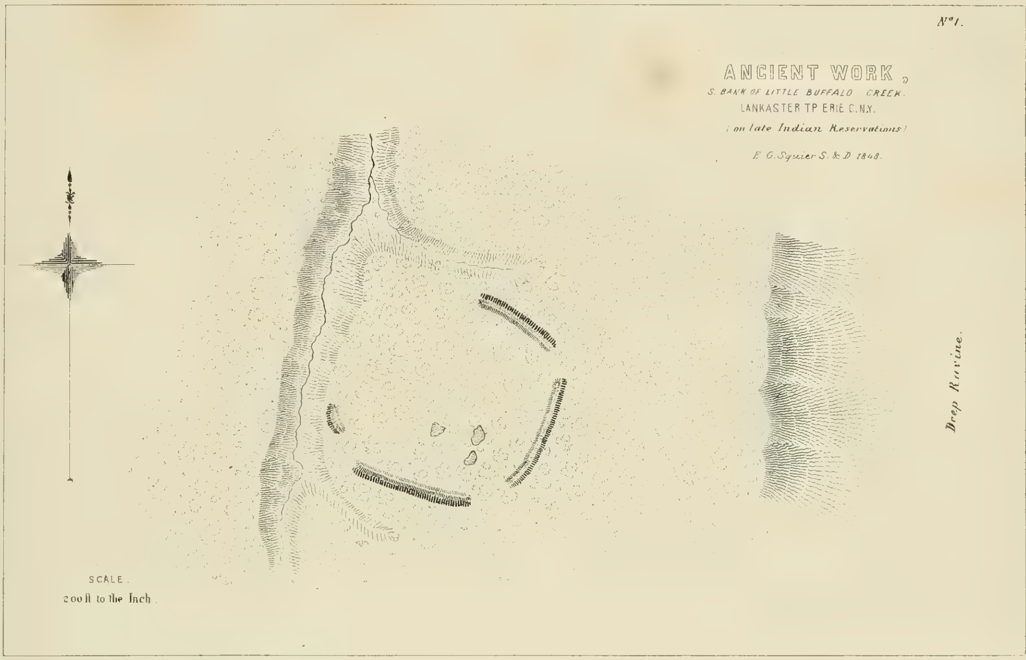


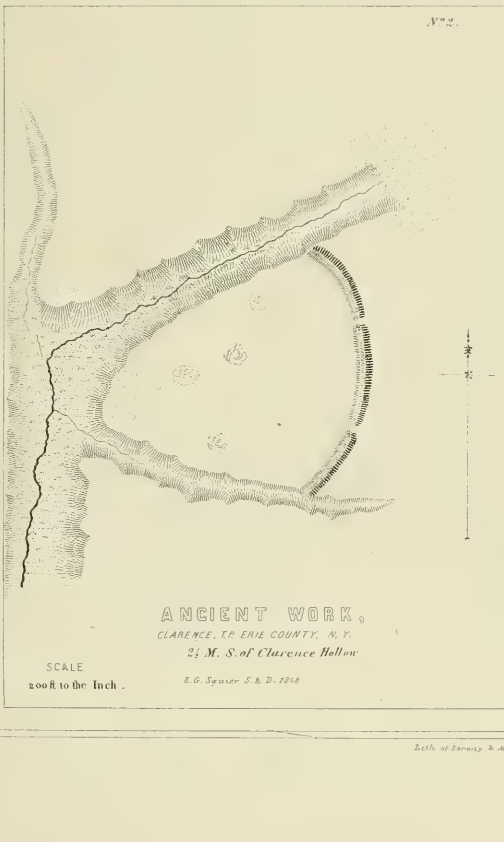


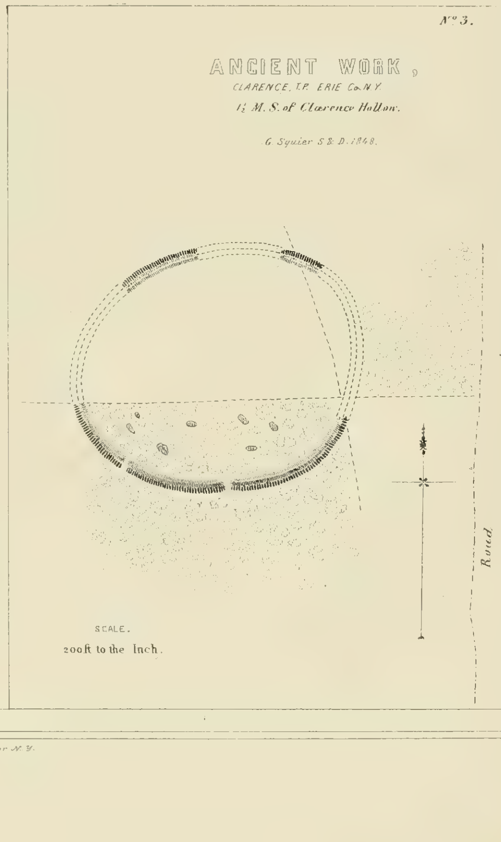


LITH OF SARONY, N. YORK.

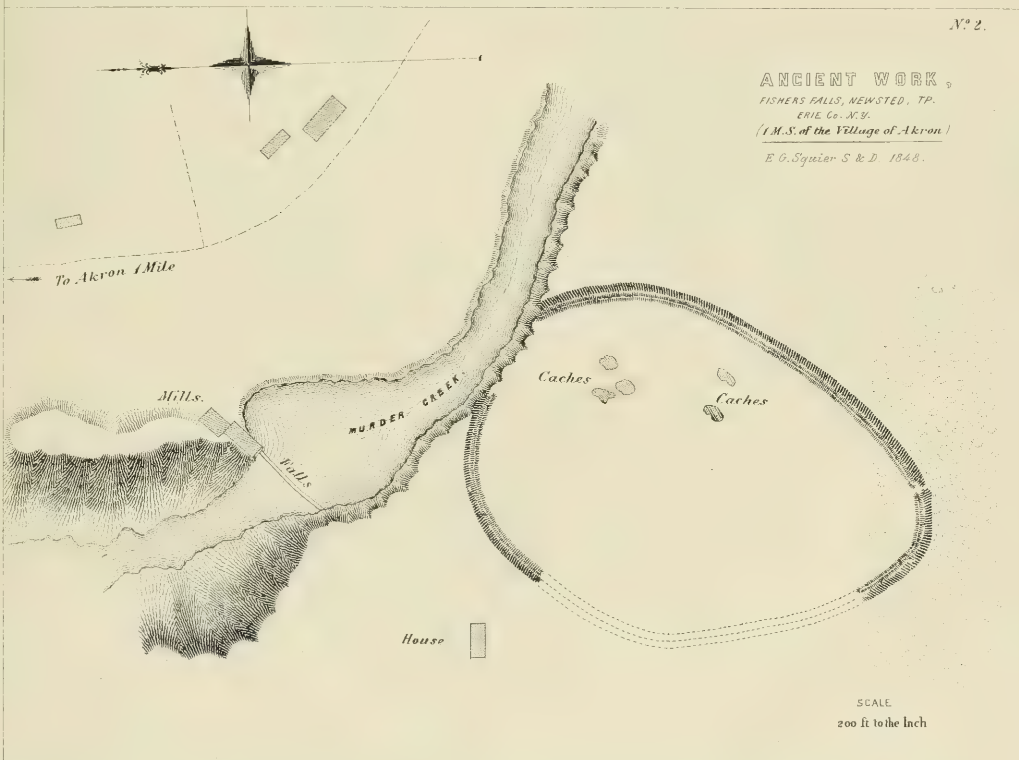
X.





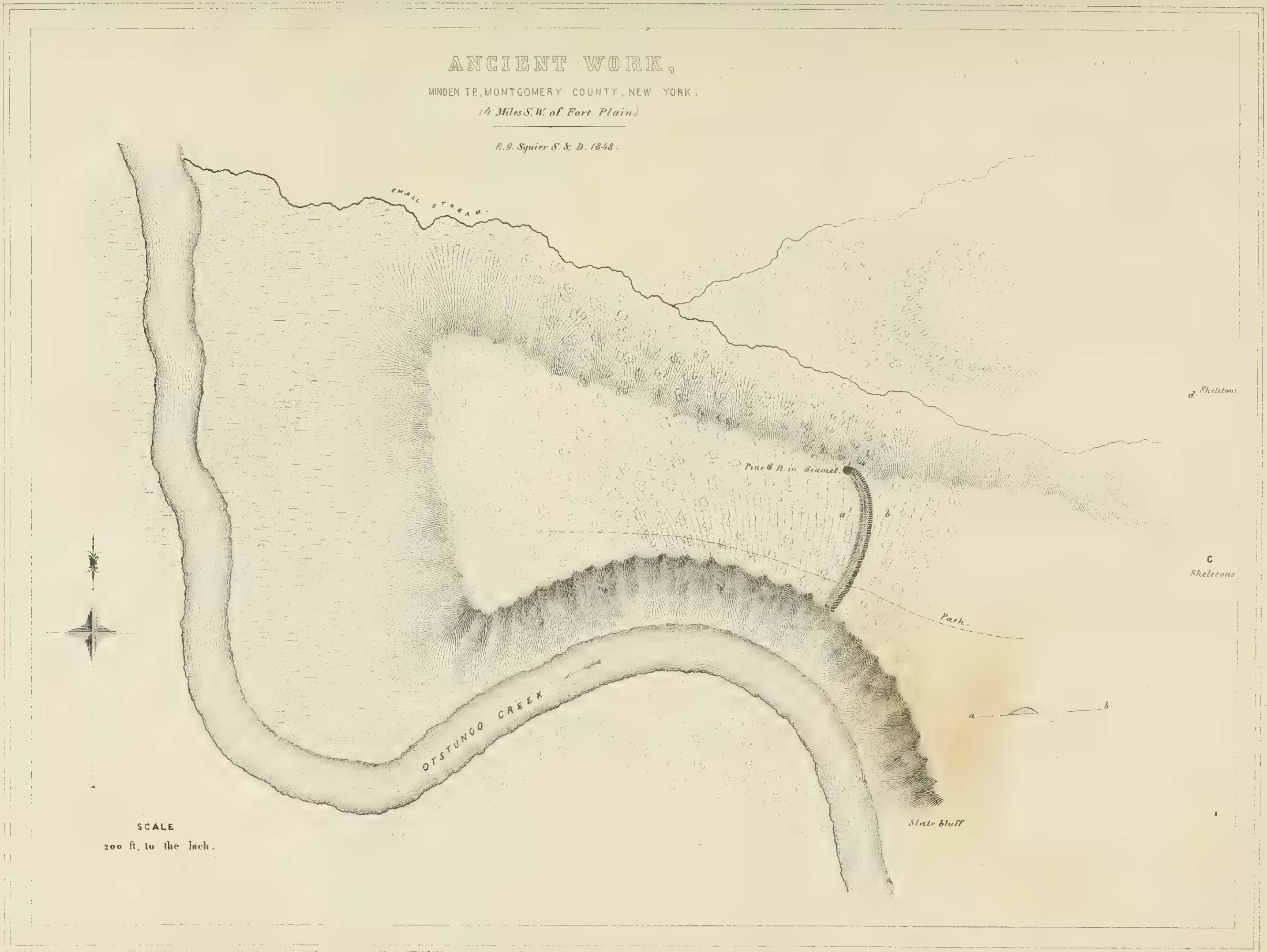


Lith. of Sarony & Major N.Y.



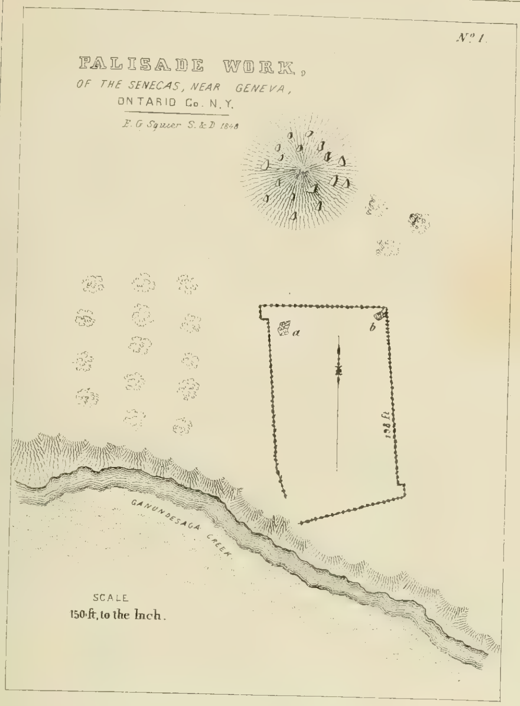
Lith. of Sarony & Major N.Y.

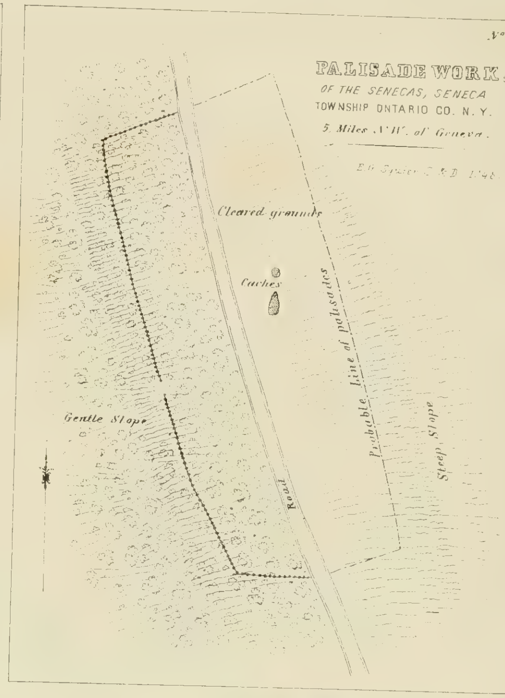
XII.

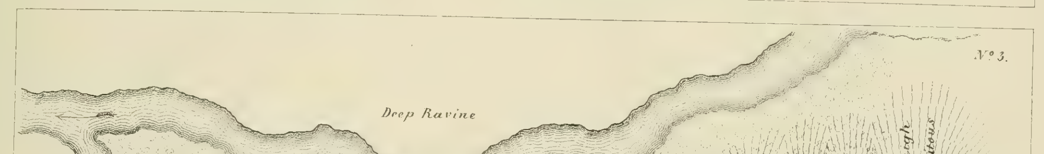


ANCIENT WORK,
MINDEN TP., MONTGOMERY COUNTY, NEW YORK.
(4 Miles S.W. of Fort Plain.)
E. G. Squier S. & D. 1848.
SMALL STREAM.
OTSTUNGO CREEK
Pine 6 ft. in diamet.
a
b
Path.
d Skeletons
C
Skeletons
a
b
Slate bluff
SCALE
200 ft. to the Inch.

XIII.

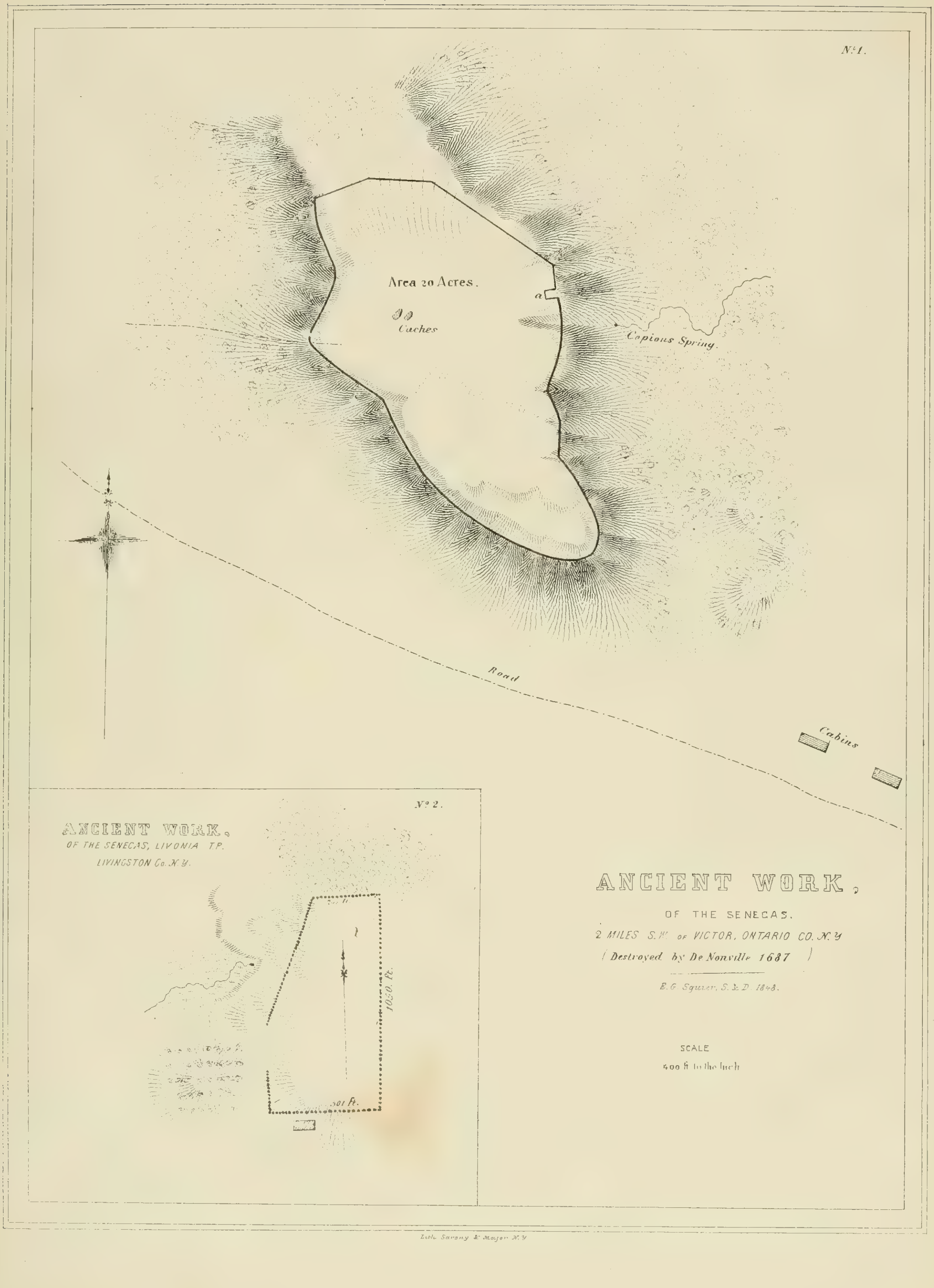






Lith of Sarony & Major N.Y.

XIV.



Lith. Sarony & Major N.Y.

APPENDIX I. TO VOLUME II.

OF THE

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

J. & G. S. GIDEON, Printers, Ninth street, Washington, D. C.

Smithsonian Institution, *April 10th*, 1849.

This Ephemeris of the planet Neptune is printed as an appendix to the second volume of the Smithsonian Contributions, for the purpose of prompt distribution among practical astronomers, with the hope that it may furnish facilities for increasing the number of observations of the opposition and quadratures of Neptune, and for the further prosecution of the study of its theory.

JOSEPH HENRY,
Secretary of the Smithsonian Institution.

WASHINGTON, *April 10th*, 1849.

TO JOSEPH HENRY, LL. D.,

Secretary of the Smithsonian Institution :

DEAR SIR: In compliance with your request, I have the pleasure to present to the Smithsonian Institution the Ephemeris of Neptune for the opposition and autumn quadrature of 1849.

In order to make the series uniform, the Ephemeris for the date of the Lalande Observations in 1795, and for the years 1846, 1847, and 1848, accompany that of 1849. They are all based upon my second elliptic elements of Neptune, the origin of which is explained in my paper dated April 15th, 1848, which will form a part of the Second volume of the Smithsonian Contributions.

EPHEMERIS OF NEPTUNE FOR COMPARISON WITH THE ANCIENT LALANDE OBSERVATIONS.

APPARENT PLACES AFFECTED WITH ABERRATION, FROM THE SECOND ELLIPTIC ELEMENTS.

Greenwich Mean Noon. Date.	Neptune's Apparent Right Ascension.	Neptune's Apparent South Declination.
	° ′ ″	° ′ ″
1795, May 8th	213 0 17.99	— 11 20 53.57
9th	212 58 46.48	— 11 20 22.88
10th	212 57 15.40	— 11 19 52.45
11th	212 55 44.79	— 11 19 22.20

The apparent Right Ascensions and Declinations of Neptune for the time of the transit over the meridian of the Paris Observatory, as observed by M. de Lalande, and reduced by *M. Mauvais, afford the following comparison with this Ephemeris:

* See Comptes Rendus, April 19th, 1847.

Date.	Obs. Right Ascen.	Observed Dec.	Obs. — Eph. d α.	Obs. Eph. d δ.
	° ′ ″	° ′ ″	″	″
1795, May 8th	212 59 35.00	— 11 20 39.10	— 1.34	+ 0.79
10th	212 56 36.30	— 11 19 38.80	+ 1.73	+ 0.31
		Mean result,	+ 0.20	+ 0.55

The Ephemeris for 1846 and 1847 is also computed from these second elliptic elements, and is referred to the date of mean midnight, Greenwich, and to the mean equinox and obliquity of January 1st, 1847. It has, however, a column for reduction to the apparent place which, when applied, gives the ordinary form of Astronomical Ephemerides, as affected with aberration.

I have added the Ephemeris for the opposition and autumn quadrature of 1848. This is a reprint in a modified form of that which was distributed in June, 1848, by the Smithsonian Institution. The change consists in the addition of the aberration time to the absolute date of the Ephemeris, so as to make it correspond in this respect to the usual form of publication of Ephemerides. A small term, amounting at most to three and a half seconds of space, which was retained in last year's Ephemeris by inadvertency, is here omitted. The present form corresponds to that of the Ephemeris of 1846 and 1847, after applying to it the reductions from the mean to the apparent places.

I have also computed, and have now the honor to present to the Smithsonian Institution, the Ephemeris for 1849, in the form of that of 1848, as remodeled above.

In the preface to my Ephemeris of 1848, it was remarked that "the theory of Neptune can hardly be expected to make farther progress till another opposition is observed."

I have now the pleasure to add, that the discussion of ninety-three meridian observations of the opposition and quadrature of 1848, and their comparison with the Ephemeris, lead me to extend the same remark to the opposition of 1849. The Ephemeris of 1848 gives places of Neptune quite as precise as the best normal places which I have been able to derive from the ninety-three European observations of that year. In other words, the averages of the series from the best observatories differ among themselves, more than either does from the actual places given by the Ephemeris.

The discussion of more than a thousand recent observations has afforded the following comparison with the theory of Neptune, since its actual discovery.

Date.			Observation — Ephemeris.			
			In R. A.		In Dec.	
			d α	No. of Obs.	d δ	No. of Obs.
			″		″	
1846,	Sept.	26	—0.21	160	+0.55	144
	Nov.	6	—0.11	343	+0.62	297
	Dec.	31	+0.95	90	+0.92	80
1847,	April	6	+0.42	15	—0.18	16
	August	22	—0.64	76	+0.19	71
	Nov.	8	—0.96	46	+0.77	51
	Dec.	18	—0.44	18	+0.89	18
1848,	August	24	—0.71	72	+0.26	72
	Nov.	10	—0.27	21	—1.23	21

I have accordingly not attempted any change in the elements used as the basis of the Ephemeris for 1849, but have employed those published in June last in the Smithsonian Contributions. As a point of reference to other publications, I would remark that the same elements called the second elliptic elements of Neptune were published in the proceedings of the American Academy for April 4th, 1848, in the communication of Professor Peirce. They were reprinted in the Proceedings of the Royal Astronomical Society, vol. viii., No. 9, page 202. I avail myself of the occasion to acknowledge the kindness of my friend, Dr. Benjamin Apthorp Gould, in making known my first elliptic elements of Neptune through his Ephemeris of this planet, published in *Schumacher's Astronomische Nachrichten, No. 646. Dr. Gould's Ephemeris presents a close agreement with observation. The small modifications of my first elements, communicated to Prof. Peirce in my letter of March 6th, 1849, which had not yet reached Dr. Gould, have led to the very satisfactory result already referred to. I subjoin the data used in computing the successive Ephemerides.

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* In No. 628 of that Journal, the eccentricity of Elements I. should read 0.00857741; also $x = [9.9998769]\, r \sin(v + 138^\circ\, 21'\, 52''.13.)$ The last correction is also required in the Proceedings A. A. S. for Dec. 7th, 1847.—*S. C. W.*

FIRST ELLIPTIC ELEMENTS.[*]

	°	′	″	
$\pi =$	48	21	2.93	mean equinox, January 1, 1847.
$\Omega =$	130	4	35.03	" " " " "
$i =$	1	46	59.54	
$e =$	0.00857741			
$\mu =$	21″.55448			
$\varepsilon =$	328° 31′ 56″.36.			Epoch for mean noon Greenwich, Jan. 1, 1847.
T =	164.6181			tropical years.

The corrections of the first elements of Neptune, [†]communicated by me to Prof. Peirce on the 6th of March, 1848, were,

		°	′	″
$d\pi =$	—	1	8	56.43
$d\Omega =$	—			14.22
$d\,i =$	—			0.57
$d\,e =$	+	0.00014205		
$d\mu =$	+			0″.0
$d\varepsilon =$	+			47.84
dT =	+			0^d.0000

Hence were obtained the second elliptic elements of Neptune, which form the basis of all the Ephemerides here offered for publication.

SECOND ELLIPTIC ELEMENTS OF NEPTUNE.

		° ′ ″	
Perihelion	$\pi =$	47 14 37.27	mean equinox, Jan. 1, 1850.
Node	$\Omega =$	130 6 51.58	" " " "
Inclination	$i =$	1 46 58.97	
Eccentricity	$e =$	0.00871946	
Mean daily motion .	$\mu =$	21″.55448	
Mean anomaly . .	M =	287° 54′ 21″.36	mean noon, Greenwich, Jan. 1, 1850.

For 1846 and 1847, the eight-day Ephemeris from these elements was compared with a former Ephemeris computed from my fourth disturbed elements, and the place was then interpolated for each day. The computations were made for the mean equinox of January 1, 1847, and the reductions to apparent places were computed, as for a fixed star, by Bessel's constants in the Nautical Almanac.

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* See my paper of April 15th, 1848, Smithsonian Contributions, Vol. ii.; also Proceedings of the American Academy for December 7th, 1847. These were used by Dr. Gould in 1848.

† See Smithsonian Contributions, above; see also Proceedings of the American Academy for April 4th, 1849, in which, however, the value of $d\,e$ should read $= + 0.00014205$.

The Ephemeris for 1848 and 1849 gives apparent places after the form of the London, Paris, and Berlin Ephemerides.

The Gaussian constants for the mean Ephemeris are derived from the node, inclination, and perihelion point, as follows:

CONSTANTS FOR THE POSITION OF THE ORBIT, REFERRED TO THE MEAN EQUINOX OF JANUARY 1, 1847.

$$23^\circ\ 29'\ 33''.32 = \omega = \text{the mean obliquity of the Ecliptic, Jan. 1, 1847.}$$

$$\tan \Psi = \frac{\tan\ i}{\cos \Omega}, \text{ for the mean place of the node.}$$

$$S = \Psi - \omega$$

$$s = \frac{\sin\ i}{\sin \Psi}$$

$$a \cos A = - \sin \Omega \cos i$$

$$a \sin A = + \cos \Omega$$

$$b \cos B = + s \cos S$$

$$b \sin B = + \sin \Omega \cos \omega$$

$$c \cos C = + s \sin S$$

$$c \sin C = + \sin \Omega \sin \omega$$

$$A' = A + (\pi - \Omega) - 0.17 \times \nu_0 = 137^\circ\ 12'\ 52''.04$$

$$B' = B + (\pi - \Omega) - 0.17 \times \nu_0 = 47^\circ\ 46'\ 27''.35$$

$$C' = C + (\pi - \Omega) - 0.17 \times \nu_0 = 43^\circ\ 53'\ 37''.36$$

$$\log a = 9.9998769$$

$$\log b = 9.9662261$$

$$\log c = 9.5800982$$

The constant part of aberration $= - 0.17 \times \nu_0 = - 3\ .67$, is adapted to an assumed value 21 .62 of the daily increase of the true anomaly. The variable part never amounts to $0''.2$. It has, however, been computed from the formula.

$$d\,A_0 = \gamma \times [- 0.17 \times d\,\nu_0 - (\Delta \times \varkappa - 0.17)\,\nu]$$

$$d\,D_0 = \gamma' \times \frac{d\ A_0}{\gamma}$$

Where Δ = Neptune's geocentric distance.

$$\gamma = \left(\frac{d\ A}{d\ v}\right)$$

$$\gamma' = \left(\frac{d\ D}{d\ v}\right)$$

$$\varkappa = \frac{8^m\ 17^s.78}{24^h\ 0^m\ 0^s} = \text{Struve's constant of aberration time.}$$

$$\log \varkappa = 7.76052$$

Having computed the true elliptic anomaly and radius vector of Neptune by the formulæ

$$\tan \tfrac{1}{2} v = \cot (45^\circ - \tfrac{1}{2} \phi) \tan \tfrac{1}{2} (\mu\, t + \varepsilon - \pi + e'' \sin \mathrm{E})$$
$$r = a\,(1 - e \cos \mathrm{E})$$

the heliocentric co-ordinates in the disturbed or instantaneous orbit are thus found:

$$x = [9.9998769] \sin (137^\circ\ 12'\ 52''.04 + v + \delta v)\,(r + \delta r)$$
$$y = [9.9662261] \sin (\ 47\ \ 46\ \ 27.35 + v + \delta v)\,(r + \delta r)$$
$$z = [9.5800982] \sin (\ 43\ \ 53\ \ 37.36 + v + \delta v)\,(r + \delta r)$$

Where, δv = Peirce's perturbations of the true anomaly.

δr = " " " radius vector.

In order that none of the data for this Ephemeris may be wanting, I subjoin Professor Peirce's second Ephemeris of the Perturbations of Neptune, from the Proceedings of the American Academy of Arts and Sciences for December, 1847.

PROFESSOR PEIRCE'S EPHEMERIS OF THE PERTURBATIONS OF NEPTUNE'S TRUE LONGITUDE AND RADIUS VECTOR, TO BE ADDED TO THE ELLIPTIC VALUES.

Date.	δv	δr
	"	
May 9, 1795	+ 47.80	+ 0.01283
October 1, 1846	27.03	0.01793
January 1, 1847	27.13	0.01728
April 1, 1847	28.88	0.01664
July 1, 1847	25.75	0.01602
October 1, 1847	24.37	0.01544
January 1, 1848	22.58	0.01491
April 1, 1848	20.40	0.01443
July 1, 1848	17.89	0.01400
October 1, 1848	15.12	0.01363
January 1, 1849	12.18	0.01332
April 1, 1849	9.06	0.01308
July 1, 1849	5.84	0.01290
October 1, 1849	+ 2.59	0.01277
January 1, 1850	— 0.64	0.01270
April 1, 1850	— 3.83	0.01270
July 1, 1850	— 6.96	0.01276
October 1, 1850	— 9.96	0.01288
January 1, 1851	— 12.64	0.01308

The Sun's co-ordinates, referred to the same equinox and equator as the heliocentric ones, are:

$$X = R \cos (\odot + \text{aberration} + \text{nutation} + \text{precession})$$

$$Y = R \sin (\odot + \quad \text{"} \quad\quad \text{"} \quad\quad \text{"} \quad) \cos \omega$$

$$Z = Y \tan \omega$$

$$\tan A_0 = \frac{y + Y}{x + X}$$

$$\tan D_0 = \frac{Z + z}{x + X} \cos A$$

$$\Delta = (z + Z) \operatorname{cosec} D$$

$$A = A_0 + \gamma \left[- 0.17 \times d\,\nu_0 - (\Delta \times \varkappa - 0.17)\, \nu \right]$$

$$D = D_0 + \gamma' \frac{d\,A_0}{\gamma}$$

This mode of computing (with a constant term for aberration) for the mean equinox, and reducing to the apparent, in the case of Neptune, saves the necessity, unless for the sake of extreme minuteness, of noticing the variable part of aberration in Right Ascension and Declination.

The Ephemerides of 1848 and 1849 have, however, been referred at once to the apparent equinox and equator, by leaving out this constant term, and interpolating from the primitive Ephemeris the daily geocentric motions. The formulæ used are the following:

$$x = a\,(r + \delta\, r) \sin (A' + v + \delta\, v)$$

$$y = b\,(r + \delta\, r) \sin (B' + v + \delta\, v)$$

$$z = c\,(r + \delta\, r) \sin (C' + v + \delta\, v)$$

$$\text{Log}\ a = 9.9998770 + 0.0000000{,}0 \times d\,\Omega + 0.0000000{,}0 \times d\,\omega$$

$$\text{Log}\ b = 9.9662367 + 0.0000000{,}2 \times d\,\Omega - 0.0000008{,}8 \times d\,\omega$$

$$\text{Log}\ c = 9.5800353 - 0.0000001{,}3 \times d\,\Omega + 0.0000051{,}1 \times d\,\omega$$

$$A' = 137^\circ\ 14'\ 14''.90 + 1''.000 \times d\,\Omega + 0''.000 \times d\,\omega$$

$$B' = 47^\circ\ 47'\ 49''.20 + 0''.991 \times d\,\Omega + 0''.030 \times d\,\omega$$

$$C' = 43^\circ\ 55'\ 2''.06 + 1''.045 \times d\,\Omega + 0''.162 \times d\,\omega$$

$\delta\, v$ = the perturbations of the elliptic true longitude v.

$\delta\, r$ = the perturbations of the elliptic true radius vector r

$d\, t$ = the aberration time in parts of a day.

Ω' = the apparent longitude of the node.

ω' = the apparent obliquity of the ecliptic.

$$d\,\Omega = \Omega' - 130^\circ\ 5'\ 40''$$

$$d\,\omega = \omega' - 23^\circ\ 27'\ 23''$$

The solar co-ordinates X, Y, and Z, were then taken from the tables in the Nautical Almanac, and the apparent Right Ascension, A_0, and Declination, D_0, of Neptune, (increased by the geocentric motion in the aberration time,) were obtained from the ordinary formulæ, already referred to, applied to the geocentric co-ordinates. The apparent values,

$$A = A_0 - \left(\frac{d\,A_0}{d\,T}\right) d\,t$$

$$D = D_0 - \left(\frac{d\,D_0}{d\,T}\right) d\,t$$

were obtained by interpolation from the primitive results.

The Ephemerides for the years 1846, 1847, 1848, and 1849, are here appended.

Yours, truly and very respectfully,

SEARS C. WALKER.

Ephemeris of Neptune, from August 4, 1846, *to February* 4, 1848, *for Greenwich mean midnight, and for the mean equinox of Jan.* 1, 1847, *with reductions to the apparent place as affected by aberration.*

Mean midnight, Greenwich.	Mean place.						Reduction to apparent place.	
Date.	Right ascension.			South declination.			In R. A.	In Dec.
d.	°	′	″	°	′	″	″	″
1846, Aug. 4.5	329	33	42.55	− 12	57	35.62	+ 7.74	+ 7.37
5.5		32	11.73		58	8.94	7.95	7.44
6.5		30	40.40		58	42.43	8.16	7.51
7.5		29	8.60		59	16.04	8.36	7.57
8.5		27	36.34	12	59	49.79	8.55	7.63
9.5		26	3.66	13	0	23.65	8 73	7.68
10.5		24	30.59		0	57.61	8.91	7.73
11.5		22	57.18		1	31.67	9.08	7.78
12.5		21	23.46		2	5.82	9.24	7.82
13.5		19	49.46		2	40.04	9.40	7.87
14.5		18	15.22		3	14.30	9.54	7.92
15.5		16	40.78		3	48.60	9.68	7.96
16.5		15	6.17		4	22.93	9.81	8.00
17.5		13	31.42		4	57.28	9.94	8.04
18.5		11	56.57		5	31.64	10.06	8 07
19.5		10	21.65		6	5.98	10.17	8.10
20.5		8	46.71		6	40.30	10.28	8.13
21.5		7	11.78		7	14.58	10 38	8.16
22.5		5	36.90		7	48.83	10.47	8.18
23.5		4	2.11		8	23.00	10.55	8.20
24.5		2	27.43		8	57.08	10.62	8.22
25.5	329	0	52.92		9	31.08	10.68	8.23
26.5	328	59	18 60		10	4.97	10.74	8.25
27.5		57	44.52		10	38.74	10.80	8.26
28.5		56	10.72		11	12.38	10 85	8.27
29.5		54	37.23		11	45.88	10.90	8.28
30.5		53	4.10		12	19.23	10.94	8.29
31.5		51	31.34		12	52.41	10.97	8.29
Sept. 1.5		49	59.03		13	25.40	10.99	8.30
2.5		48	27.21		13	58.20	11.00	8.29
3.5		46	55.90		14	30.80	11.00	8.29
4.5		45	25.13		15	3.19	11.00	8.29
5.5		43	54.92		15	35.34	10.99	8.28
6.5		42	25.31		16	7.24	10 98	8.27
7.5		40	56.32		16	38.91	10.96	8.26
8.5		39	27.99		17	10.31	10.94	8.25
9.5		38	0.34		17	41.44	10.91	8.23
10.5		36	33.40		18	12.29	10.87	8.21
11.5		35	7.19		18	42.85	10.82	8.19
12.5		33	41.76		19	13.10	10.77	8.17
13.5		32	17.16		19	43.04	10.71	8.15
14.5		30	53.41		20	12.64	10.65	8.12

Ephemeris of Neptune—Continued.

Mean midnight, Greenwich.	Mean place.						Reduction to apparent place.	
Date.	Right ascension.			South declination.			In R. A.	In Dec.
d.	°	′	″	°	′	″	″	″
1846, Sept. 15.5	328	29	30.56	— 13	20	41.90	+ 10.58	+ 8.09
16.5		28	8.64		21	10.80	10.50	8.06
17.5		26	47.67		21	39.34	10.41	8.03
18.5		25	27.70		22	7.50	10.32	8.00
19.5		24	8.78		22	35.26	10.23	7.97
20.5		22	50.92		23	2.63	10.13	7 94
21.5		21	34.15		23	29.57	10.03	7.90
22.5		20	18.51		23	56.13	9.92	7.86
23.5		19	4.05		24	22.23	9.80	7.82
24.5		17	50.79		24	47.89	9.68	7.78
25.5		16	38.77		25	13.11	9.55	7.74
26 5		15	28.02		25	37.85	9.42	7.70
27.5		14	18.53		26	2.12	9.29	7.65
28.5		13	10.35		26	25.90	9.15	7.60
29.5		12	3.51		26	49.20	9.01	7.55
30.5		10	58 03		27	12.00	8.86	7.50
Oct. 1.5		9	53.94		27	34.30	8.71	7.45
2.5		8	51.24		27	56.10	8.55	7.40
3.5		7	49.97		28	17.36	8.38	7.35
4.5		6	50.13		28	38.11	8.21	7.30
5.5		5	51.76		28	58.32	8.04	7.25
6.5		4	54.89		29	17 99	7.87	7.20
7.5		3	59.56		29	37.10	7 70	7.14
8.5		3	5.78		29	55.66	7.52	7.08
9.5		2	13.58		30	13.65	7.33	7.03
10.5		1	22.98		30	31.08	7.14	6.97
11.5	328	0	34.01		30	47.89	6.95	6.91
12.5	327	59	46.66		31	4.14	6.76	6.85
13.5		59	0.99		31	19.79	6.57	6.79
14.5		58	16.98		31	34.83	6.37	6.73
15.5		57	34.72		31	49.26	6.17	6.67
16.5		56	54.17		32	3.08	5.96	6.61
17.5		56	15.37		32	16.29	5.76	6.55
18.5		55	38.34		32	28.86	5.55	6.48
19.5		55	3.12		32	40.78	5.34	6.42
20.5		54	29.71		32	52.07	5.12	6.36
21.5		53	58.12		33	2.71	4.91	6.30
22.5		53	28.37		33	12.71	4.70	6.24
23.5		53	0.46		33	22.04	4.48	6.17
24.5		52	34.42		33	30.72	4.26	6.11
25.5		52	10 24		33	38.75	4.04	6.05
26.5		51	47.94		33	46.15	3.81	5.98
27.5		51	27.53		33	52.89	3.59	5.92
28.5		51	9.04		33	58.82	3.37	5.85

Ephemeris of Neptune—Continued.

Mean midnight, Greenwich.	Mean place.						Reduction to apparent place.	
Date.	Right ascension.			South declination.			In R. A.	In Dec.
d.	°	′	″	°	′	″	″	″
1846, Oct. 29.5	327	50	52.46	— 13	34	4.16	+ 3.14	+ 5.79
30 5		50	37.79		34	8.84	2.92	5.72
31.5		50	25.06		34	12.83	2.69	5.66
Nov. 1.5		50	14.27		34	16.11	2 47	5.60
2.5		50	5.41		34	18.76	2 24	5.53
3.5		49	58.51		34	20.72	2.02	5.47
4.5		49	53.56		34	21.97	1.79	5.40
5 5		49	50 57		34	22.55	1 57	5 34
6.5		49	49 56		34	22.44	1.34	5.27
7.5		49	50.56		34	21.64	1.12	5.20
8 5		49	53.49		34	20.15	0.89	5.14
9.5		49	58.40		34	17.97	0.67	5 07
10 5		50	5.26		34	15.09	0.44	5.01
11.5		50	14.16		34	11.52	0.22	4.94
12.5		50	25.08		34	7 24	— 0.01	4.88
13.5		50	38.00		34	2.26	0.23	4.82
14.5		50	52 94		33	56.58	0 45	4.75
15.5		51	9.88		33	50.21	0.67	4.69
16.5		51	28.82		33	43 14	0.89	4.62
17 5		51	49.76		33	35.37	1.11	4.56
18.5		52	12.63		33	26.91	1.32	4.50
19.5		52	37.62		33	17.75	1.53	4.44
20.5		53	4.54		33	7.89	1.74	4.37
21.5		53	33.47		32	57.33	1.95	4 31
22.5		54	4.38		32	46.08	2.16	4.25
23.5		54	37.26		32	34.14	2.36	4.19
24.5		55	12.10		32	21.52	2.57	4.13
25.5		55	48.90		32	8.24	2.77	4.07
26.5		56	27.66		31	54.26	2.97	4 01
27.5		57	8.35		31	39 60	3.17	3.95
28.5		57	50.97		31	24.29	3.36	3.89
29.5		58	35.51		31	8.32	3.55	3.83
30.5	327	59	21.95		30	51 66	3.74	3.77
Dec. 1.5	328	0	10.30		30	34.35	3.93	3.72
2.5		1	0.53		30	16.39	4.12	3.67
3.5		1	52.63		29	57 78	4.30	3.61
4.5		2	46.61		29	38.51	4.48	3.56
5.5		3	42.46		29	18.61	4.66	3.50
6.5		4	40.17		28	58.04	4.83	3 45
7.5		5	39.70		28	36.85	5.00	3.40
8.5		6	41.07		28	15.03	5.17	3.35
9.5		7	44.23		27	52.57	5.33	3.30
10 5		8	49.18		27	29.49	6.49	3.25

Ephemeris of Neptune—Continued.

Mean midnight, Greenwich.	Mean place.						Reduction to apparent place.	
Date.	Right ascension.			South declination.			In R. A.	In Dec.
d.	°	′	″	°	′	″	″	″
1846, Dec. 11.5	328	9	55.90	— 13	27	5.79	— 5.65	+ 3.20
12.5		11	4.39		26	41.47	5.81	3.15
13.5		12	14.63		26	16.54	5.96	3.10
14.5		13	26.60		25	51.03	6.11	3.05
15.5		14	40.32		25	24.90	6.26	3.00
16.5		15	55.76		24	58.17	6.40	2.96
17.5		17	12.89		24	30.86	6.53	2.92
18.5		18	31.68		24	2.96	6.66	2.87
19.5		19	52.08		23	34.49	6.79	2.82
20.5		21	14.11		23	5.46	6.92	2.78
21.5		22	37.74		22	35.86	7.05	2.74
22.5		24	2.94		22	5 72	7.17	2.70
23.5		25	29 70		21	35.04	7.29	2.66
24.5		26	57.98		21	3.83	7.40	2 62
25.5		28	27.80		20	32.10	7.51	2.58
26.5		29	59.08		19	59.84	7.61	2.54
27.5		31	31.87		19	27.03	7.71	2.50
28.5		33	6.05		18	53.70	7.80	2.46
29 5		34	41.67		18	19.86	7 89	2.42
30.5		36	18.67		17	45.54	7.98	2.39
31.5		37	57.05		17	10.78	8.07	2.36
1847, Jan. 1.5		39	36.74		16	35.60	8.16	2.33
2.5		41	17.76		15	59.95	8.24	2.30
3.5		43	0.06		15	23.84	8.32	2.27
4.5		44	43.62		14	47.25	8.39	2.24
5.5		46	28.46		14	10.21	8.45	2.21
6.5		48	14.54		13	32.71	8.51	2.18
7.5		50	1.81		12	54.80	8 57	2.15
8.5		51	50.27		12	16.48	8.62	2.12
9.5		53	39.87		11	37.76	8.67	2.10
10.5		55	30.61		10	58.66	8.72	2.08
11.5		57	22.44		10	19.16	8.77	2.06
12.5	328	59	15.35		9	39.30	8.81	2.04
13.5	329	1	9.29		8	59.04	8.85	2.02
14.5		3	4.24		8	18.43	8.88	2.00
15.5		5	0.19		7	37.45	8.90	1.98
16.5		6	57.10		6	56.15	8.92	1.96
17.5		8	54.93		6	14.52	8.94	1.94
18.5		10	53.68		5	32.56	8.96	1.92
19.5		12	53.29		4	50.30	8.97	1.90
20.5		14	53.74		4	7.72	8.98	1.89
21.5		16	55.00		3	24.86	8.99	1.88
22.5		18	57.05		2	41.73	9.00	1.87
23.5		20	59.83		1	58.32	9.01	1.86

Ephemeris of Neptune—Continued.

Mean midnight, Greenwich.	Mean place.						Reduction to apparent place.	
Date.	Right ascension.			South declination.			In R. A.	In Dec.
d.	°	′	″	°	′	″	″	″
1847, Jan. 24.5	329	23	3.32	— 13	1	14.66	— 9 00	+ 1.85
25.5		25	7.48	13	0	30.79	8 99	1.84
26.5		27	12.30	12	59	46.67	8.97	1.83
27.5		29	17.74		59	2.33	8.95	1.83
28 5		31	23.78		58	17.78	8.93	1.82
29.5		33	30.39		57	33.04	8.90	1.82
30.5		35	37.53		56	48.09	8.87	1.81
31.5		37	45.19		56	2.95	8.84	1.81
Feb. 1.0		38	49.21		55	40.20	8.82	1.81
9.0	329	56	6.71		49	33.03	8.39	1.87
17.0	330	13	38.97		43	20.36	7.69	2.03
25.0		31	9.72		37	8.06	6.71	2.31
March 5.0	330	48	23.41		31	1.74	5.45	2.70
13.0	331	5	5.96		25	6.61	3.92	3.23
21.0		21	2.71		19	28.04	2.12	3.87
21.5		22	0.66		19	7.55	1.99	3.90
22.5		23	55.84		18	26.85	1.74	4.01
23.5		25	50.02		17	46.49	1.49	4.11
24.5		27	43.23		17	6.50	1.23	4.21
25.5		29	35.41		16	26.88	0.97	4.31
26.5		31	26.53		15	47.65	0 71	4.42
27.5		33	16.60		15	8.80	0.44	4.53
28.5		35	5.57		14	30.36	0.17	4.63
29.5		36	53.43		13	52.33	+ 0.11	4.74
30 5		38	40.16		13	14.72	0 39	4.84
31.5		40	25.74		12	37.55	0.68	4.95
April 1.5		42	10.10		12	0 81	0 98	5.05
2.5		43	53.27		11	24.49	1.28	5.16
3.5		45	35.21		10	48 61	1.59	5.27
4.5		47	15.92		10	13.19	1.90	5.39
5.5		48	55.34		9	38.25	2.21	5.51
6.5		50	33.51		9	3.77	2.53	5.63
7.5		52	10.37		8	29.77	2.85	5.76
8.5		53	45.91		7	56.26	3.17	5.88
9.5		55	20.12		7	23.25	3.49	6.00
10.5		56	52.95		6	50.76	3.82	6.13
11.5		58	24.34		6	18.79	4.15	6.26
12.5	331	59	54.37		5	47.34	4.49	6.40
13.5	332	1	22.93		5	16.40	4.83	6.54
14.5		2	50.01		4	46.00	5.18	6.68
15.5		4	15.62		4	16.15	5.53	6.82
16.5		5	39.79		3	46.85	5.89	6.96

Ephemeris of Neptune—Continued.

Mean midnight, Greenwich.	Mean place.						Reduction to apparent place.	
Date.	Right ascension.			South declination.			In R. A.	In Dec.
d.	°	′	″	°	′	″	″	″
1847, April 17.5	332	7	2.40	— 12	3	18.12	+ 6.25	+ 7.10
18.5		8	23.49		2	49.95	6.62	7.24
19.5		9	43.03		2	22.35	6.99	7.38
20.5		11	1.01		1	55.32	7.37	7.52
21.5		12	17.41		1	28.89	7.75	7.66
22.5		13	32.20		1	3.04	8.18	7.81
23.5		14	45.38		0	37.81	8.51	7.96
24.5		15	56.93	12	0	13.17	8.90	8.11
25.5		17	6.86	11	59	49.14	9.29	8.27
26.5		18	15.12		59	25.72	9.68	8.43
27.5		19	21.75		59	2.91	10.08	8.59
28.5		20	26.69		58	40.73	10.48	8.75
29.5		21	29.95		58	19.18	10.89	8.91
30.5		22	31.52		57	58.25	11.30	9.07
May 1.5		23	31.38		57	37.95	11.71	9.23
2.5		24	29.55		57	18.30	12.13	9.39
3.5		25	26.00		56	59.29	12.55	9.56
4.5		26	20.72		56	40.92	12.97	9.73
5.5		27	13.66		56	23.21	13.39	9.90
6.5		28	4.82		56	6.15	13.81	10.07
7.5		28	54.22		55	49.75	14.24	10.24
8.5		29	41.82		55	34.01	14.67	10.41
9.5		30	27.62		55	18.95	15.10	10.58
10.5		31	11.60		55	4.56	15.53	10.75
11.5		31	53.78		54	50.84	15.96	10.92
12.5		32	34.13		54	37.80	16.40	11.09
13.5		33	12.65		54	25.43	16.84	11.26
14.5		33	49.32		54	13.75	17.29	11.43
15.5		34	24.14		54	2.75	17.74	11.61
16.5		34	57.09		53	52.45	18.19	11.79
17.5		35	28.18		53	42.84	18.64	11.97
18.5		35	57.39		53	33.93	19.09	12.15
19.5		36	24.74		53	25.72	19.54	12.33
20.5		36	50.22		53	18.20	20.00	12.51
21.5		37	13.83		53	11.38	20.46	12.69
22.5		37	35.58		53	5.23	20.92	12.86
23.5		37	55.44		52	59.79	21.38	13.04
24.5		38	13.44		52	55.03	21.84	13.22
25.5		38	29.56		52	50.98	22.30	13.40
26.5		38	43.80		52	47.61	22.76	13.58
27.5		38	56.18		52	44.92	23.22	13.76
28.5		39	6.69		52	42.95	23.68	13.94
29.5		39	15.31		52	41.66	24.14	14.12
30.5		39	22.05		52	41.06	24.61	14.30

Ephemeris of Neptune—Continued.

Mean midnight, Greenwich.	Mean place.						Reduction to apparent place.	
Date.	Right ascension.			South declination.			In R. A.	In Dec.
d.	°	′	″	°	′	″	″	″
1847, May 31.5	332	39	26.93	— 11	52	41.15	+ 25.07	+ 14.48
June 1.5		39	29.92		52	41.94	25 53	14.66
2.5		39	31.10		52	43.41	26 00	14.83
3.5		39	30.43		52	45.56	26.46	15.01
4.5		39	27.91		52	48.40	26.93	15.18
5.5		39	23.53		52	51.92	27.40	15.35
6.5		39	17.28		52	56.13	27.86	15.53
7.5		39	9.17		53	1.02	28.33	15.70
8.5		38	59.22		53	6.59	28.79	15.87
9.5		38	47.42		53	12.84	29.25	16.05
10.5		38	33.77		53	19.77	29.71	16.22
11.5		38	18.30		53	27.35	30.17	16.40
12.5		38	1.00		53	35.62	30.63	16.57
13.5		37	41.90		53	44.55	31.09	16.74
14.5		37	20.99		53	54.14	31.55	16.92
15.5		36	58.29		54	4.36	32.00	17.09
16.5		36	33.80		54	15.25	32.45	17.26
17.5		36	7.54		54	26.80	32.90	17.44
18.5		35	39.52		54	38.98	33.35	17.61
19.5		35	9.74		54	51.79	33.80	17.78
20.5		34	38.24		55	5.25	34.25	17.96
21.5		34	5.01		55	19.32	34.70	18.12
22.5		33	30.08		55	34.02	35.15	18.27
23.5		32	53.48		55	49.32	35.60	18.43
24.5		32	15.22		56	5.23	36.04	18.59
25.5		31	35.32		56	21.72	36.48	18.75
26.5		30	53.81		56	38.81	36.92	18.90
27.5		30	10.68		56	56.48	37.36	19.05
28.5		29	25.95		57	14.72	37.79	19.20
29.5		28	39.64		57	33.54	38.22	19.36
30.5		27	51.76		57	52.93	38.64	19.51
July 1.5		27	2.30		58	12.88	39.05	19.66
2.5		26	11.29		58	33.39	39.45	19.81
3.5		25	18.76		58	54.44	39.84	19.95
4.5		24	24.72		59	16.02	40.22	20.09
5.5		23	29.18	11	59	38.15	40.60	20.23
6.5		22	32.19	12	0	0.79	40.98	20.37
7.5		21	33.76		0	23.95	41.36	20.51
8.5		20	33.90		0	47.62	41.73	20.65
9.5		19	32.63		1	11.79	42.10	20.79
10.5		18	29.99		1	36.46	42.47	20.93
11.5		17	25.98		2	1.59	42.84	21.06
12.5		16	20.61		2	27.21	43.21	21.19

Ephemeris of Neptune—Continued.

Mean midnight, Greenwich.	Mean place.						Reduction to apparent place.	
Date.	Right ascension.			South declination.			In R. A.	In Dec.
d.	°	′	″	°	′	″	″	″
1847, July 13.5	332	15	13.94	— 12	2	53.27	+ 43.58	+ 21.30
14.5		14	5.98		3	19.81	43.94	21.43
15.5		12	56.78		3	46.77	44.30	21.55
16.5		11	46.34		4	14.18	44.65	21.67
17.5		10	34.71		4	41.98	44.99	21.78
18.5		9	21.91		5	10.19	45 32	21.89
19.5		8	7.97		5	38.80	45.65	22.00
20.5		6	52.91		6	7.81	45 98	22.11
21.5		5	36.75		6	37.17	46.30	22.21
22.5		4	19.54		7	6.90	46.61	22.31
23.5		3	1.31		7	36.98	46.92	22.41
24.5		1	42.07		8	7 41	47.23	22.51
25.5	332	0	21.87		8	38.16	47.52	22.61
26.5	331	59	0.72		9	9.23	47.80	22.70
27.5		57	38.66		9	40.62	48.08	22.79
28.5		56	15.71		10	12.29	48.36	22.88
29.5		54	51.91		10	44.24	48.64	22.97
30.5		53	27.28		11	16.47	48.91	23.05
31 5		52	1.87		11	48.95	49.17	23.13
Aug. 1.5		50	35.69		12	21 69	49.42	23.20
2.5		49	8.78		12	54.67	49.67	23.27
3.5		47	41.15		13	27.89	49.91	23.34
4.5		46	12.84		14	1.32	50.14	23.41
5.5		44	43 87		14	34.95	50.36	23.48
6.5		43	14.29		15	8.78	50.57	23.55
7.5		41	44.13		15	42.79	50.78	23.62
8.5		40	13.43		16	16.97	50 99	23.69
9.5		38	42.26		16	51.30	51.20	23.75
10.5		37	10.63		17	25.76	51.40	23.81
11.5		35	38.55		18	0.34	51.58	23.86
12.5		34	6.07		18	35.04	51.75	23.91
13.5		32	33.23		19	9.84	51.92	24.06
14.5		31	0.06		19	44.73	52.08	24.10
15.5		29	26.61		20	19.69	52.24	24.14
16.5		27	52.90		20	54.71	52.39	24.18
17.5		26	18.99		21	29 77	52.53	24.21
18.5		24	44.90		22	4.87	52.67	24.23
19.5		23	10.66		22	39.99	52.79	24.25
20.5		21	36.29		23	15.09	52.90	24.27
21.5		20	1.84		23	50.18	53.01	24.28
22.5		18	27.39		24	25.25	53.12	24.29
23.5		16	52.96		25	0.29	53.22	24.30
24.5		15	18.56		25	35.27	53.32	24.31
25.5		13	44.22		26	10.20	53.41	24.32

Ephemeris of Neptune—Continued.

Mean midnight, Greenwich.	Mean place.						Reduction to apparent place.	
Date.	Right ascension.			South declination.			In R. A.	In Dec.
d.	°	′	″	°	′	″	″	″
1847, Aug. 26.5	331	12	9.99	— 12	26	45.05	+ 53.49	+ 24.33
27.5		10	35.89		27	19.82	53.56	24.34
28.5		9	1.95		27	54.50	53.62	24.35
29.5		7	28.22		28	29.08	53.68	24.36
30.5		5	54.74		29	3.53	53.73	24.37
31 5		4	21 53		29	37.83	53.77	24.38
Sept. 1.5		2	48.65		30	11 99	53.80	24.38
2.5	331	1	16.13		30	45.98	53.83	24 37
3.5	330	59	44.00		31	19.81	53.85	24.36
4.5		58	12.29		31	53 44	53.86	24.35
5.5		56	41.02		32	26.88	53.86	24.34
6.5		55	10 23		33	0.12	53.87	24.33
7 5		53	39.97		33	33.12	53.87	24.32
8.5		52	10.28		34	5.89	53.86	24.31
9.5		50	41 20		34	38.42	53.85	24.29
10.5		49	12.75		35	10.68	53.83	24.27
11.5		47	45.01		35	42 64	53.80	24.25
12.5		46	17.97		36	14.36	53.76	24.23
13.5		44	51.71		36	45.71	53.71	24.20
14.5		43	26.24		37	16.76	53.66	24.17
15.5		42	1.60		37	47.49	53.60	24.14
16.5		40	37.81		38	17.87	53.54	24.11
17.5		39	14.90		38	47.90	53.48	24.08
18.5		37	52 92		39	17.56	53.41	24.04
19.5		36	31.88		39	46.88	53.33	24.01
20.5		35	11.82		40	15.80	53.24	23.98
21.5		33	52.77		40	44 33	53.15	23.94
22.5		32	34.76		41	12.46	53 05	23.90
23.5		31	17.82		41	40.16	52.95	23.86
24.5		30	1.98		42	7.44	52.84	23.82
25.5		28	47.27		42	34.30	52 73	23.78
26.5		27	33 73		43	0.71	52.62	23.74
27.5		26	21.40		43	26.66	52.50	23.70
28.5		25	10.26		43	52.15	52 37	23.66
29.5		24	0.34		44	17.16	52.24	23.61
30.5		22	51.69		44	41.70	52.10	23.56
Oct. 1.5		21	44.36		45	5.75	51.96	23.51
2.5		20	38 35		45	29.29	51.81	23.46
3.5		19	33.70		45	52.32	51.66	23.41
4.5		18	30.45		46	14.83	51.51	23.35
5.5		17	28.60		46	36.81	51.39	23.29
6.5		16	28.21		46	58.25	51.23	23.23
7.5		15	29.28		47	19.13	51.05	23.18

Ephemeris of Neptune—Continued.

Mean midnight, Greenwich.	Mean place.						Reduction to apparent place.	
Date.	Right ascension.			South declination.			In R. A.	In Dec.
d.	°	′	″	°	′	″	″	″
1847, Oct. 8.5	330	14	31.87	— 12	47	39.45	+ 50.86	+ 23.12
9.5		13	35.98		47	59.21	50.67	23.06
10.5		12	41.64		48	18.39	50.48	23.00
11.5		11	48.86		48	37.00	50.29	22.94
12.5		10	57.68		48	55.01	50.10	22.88
13.5		10	8.10		49	12.42	49.91	22.82
14.5		9	20.17		49	29.23	49.72	22.75
15.5		8	33.91		49	45.43	49.54	22.69
16.5		7	49.32		50	1.00	49.35	22.62
17.5		7	6.43		50	15.95	49.17	22.56
18.5		6	25.24		50	30.27	48.99	22.49
19.5		5	45.77		50	43.94	48.80	22.43
20.5		5	8.05		50	57.01	48.60	22.36
21.5		4	32.11		51	9.41	48.40	22.30
22.5		3	57.94		51	21.17	48.19	22.23
23.5		3	25.54		51	32.28	47.98	22.16
24.5		2	54.94		51	43.75	47.77	22.09
25.5		2	26.16		51	52.54	47.56	22.03
26.5		1	59.22		52	1.67	47.35	21.96
27.5		1	34.12		52	10.12	47.13	21.89
28.5		1	10.87		52	17.89	46.90	21.81
29.5		0	49.53		52	24.98	46.68	21.74
30.5		0	30.06		52	31.39	46.46	21.67
31.5	330	0	12.49		52	37.11	46.24	21.60
Nov. 1.5	329	59	56.83		52	42.14	46.01	21.53
2.5		59	43.09		52	46.47	45.79	21.46
3.5		59	31.29		52	50.10	45.57	21.39
4.5		59	21.42		52	53.04	45.35	21.32
5.5		59	13.50		52	55.27	45.12	21.25
6.5		59	7.56		52	56.80	44.90	21.18
7.5		59	3.58		52	57.61	44.68	21.11
8.5		59	1.59		52	57.70	44.46	21.04
9.5		59	1.58		52	57.07	44.24	20.97
10.5		59	3.56		52	55.74	44.02	20.90
11.5		59	7.53		52	53.69	43.80	20.83
12.5		59	13.47		52	50.93	43.58	20.77
13.5		59	21.41		52	47.46	43.36	20.70
14.5		59	31.33		52	43.27	43.14	20.63
15.5		59	43.25		52	38.37	42.92	20.57
16.5	329	59	57.17		52	32.74	42.70	20.50
17.5	330	0	13.10		52	26.40	42.48	20.43
18.5		0	30.96		52	19.33	42.26	20.37
19.5		0	50.76		52	11.63	42.05	20.30
20.5		1	12.56		52	3.17	41.84	20.23

Ephemeris of Neptune—Continued.

Mean midnight, Greenwich.	Mean places.		Reduction to apparent place.	
Date.	Right ascension.	South declination.	In R. A.	In Dec.
d.	° ′ ″	° ′ ″	″	″
1847, Nov. 21.5	330 1 36.36	— 12 51 54.02	+ 41.62	+ 20.17
22.5	2 2.15	51 44.15	41.41	20.10
23.5	2 29.90	51 33.58	41.21	20.04
24.5	2 59.60	51 22.30	41.01	19.97
25.5	3 31.25	51 10.32	40.81	19.91
26.5	4 4.86	50 57.64	40.61	19.85
27.5	4 40.41	50 44.27	40.41	19.79
28.5	5 17.92	50 30.19	40.21	19.73
29.5	5 57.37	50 15.44	40.01	19.67
30.5	6 38.75	49 59.98	39.81	19.61
Dec. 1.5	7 22.07	49 43.84	39.61	19.55
2.5	8 7.31	49 27.00	39.42	19.49
3.5	8 54.48	49 9.49	39.24	19.43
4.5	9 43.54	48 51.28	39.06	19.37
5.5	10 34.49	48 32.40	38.88	19.31
6.5	11 27.32	48 12.84	38.70	19.25
7.5	12 22.01	47 52.63	38.52	19.19
8.5	13 18.54	47 31.75	38.34	19.14
9.5	14 16.92	47 10.22	38.16	19.09
10.5	15 17.11	46 48.05	37.98	19.04
11.5	16 19.14	46 25.23	37.81	18.99
12.5	17 22.94	46 1.78	37.64	18.94
13.5	18 28.51	45 37.70	37 48	18.89
14.5	19 35.86	45 12.99	37.32	18.84
15.5	20 44.94	44 47.65	37.17	18.79
16.5	21 55.74	44 21.69	37.02	18.74
17.5	23 8.25	43 55.13	36.87	18.69
18.5	24 22.44	43 27.98	36.73	18.65
19.5	25 38.30	43 0.20	36.59	18.60
20.5	26 55.80	42 31.85	36.45	18.55
21.5	28 14.93	42 2.90	36.32	18.51
22.5	29 35.68	41 33.37	36.19	18.46
23.5	30 58.03	41 3.27	36.06	18.42
24.5	32 21.96	40 32.61	35.94	18.38
25.5	33 47.44	40 1.41	35.82	18.34
26.5	35 14.46	39 29.67	35.70	18.30
27.5	36 42.99	38 57.37	35.59	18.26
28.5	38 13.01	38 24.53	35.48	18.22
29.5	39 44.50	37 51.17	35.37	18.18
30.5	41 17.45	37 17.30	35.26	18.14
31.5	42 51.83	36 42.89	35.16	18.10
1848, Jan. 1.5	44 27.63	36 7.99	35.06	18.06
2.5	46 4.81	35 32.59	34.97	18.03

Ephemeris of Neptune—Continued.

Mean midnight, Greenwich.		Mean place.						Reduction to apparent place.	
Date.		Right ascension.			South declination.			In R. A.	In Dec.
	d.	°	′	″	°	′	″	″	″
1848, Jan.	3.5	330	47	43.87	— 12	34	56.69	+ 34.89	+ 18.00
	4.5		49	23.26		34	20.32	34.81	17.97
	5.5		51	4.47		33	43.46	34.73	17.94
	6.5		52	46.98		33	6.12	34.65	17.91
	7.5		54	30.73		32	28.34	34.58	17.88
	8.5		56	15.71		31	50.11	34.51	17.85
	9.5		58	1.91		31	11.45	34.45	17.82
	10.5	330	59	49.27		30	32.35	34.39	17.80
	11 5	331	1	37.78		29	52.86	34.33	17.78
	12.5		3	27.41		29	12.96	34.27	17.76
	13.5		5	18.14		28	32.66	34.22	17.74
	14 5		7	9.93		27	51.98	34.18	17.72
	15.5		9	2.75		27	10.93	34.14	17.70
	16.5		10	56.58		26	29.51	34.10	17.68
	17.5		12	51.41		25	47.74	34.06	17.66
	18.5		14	47.18		25	5.62	34.03	17.64
	19.5		16	43.87		24	23.19	34.00	17.62
	20.5		18	41.44		23	40.42	33 97	17.61
	21.5		20	39.87		22	57.35	33.94	17.60
	22.5		22	39.16		22	13.99	33.92	17.59
	23.5		24	39.26		21	30.33	33.90	17.58
	24.5		26	40.16		20	46.37	33.88	17.57
	25.5		28	41.81		20	2.13	33.87	17.56
	26.5		30	44.22		19	17.62	33.86	17.55
	27.5		32	47.34		18	32.82	33.87	17.54
	28.5		34	51.11		17	47.75	33.88	17 53
	29.5		36	55.57		17	2.46	33.90	17.52
	30.5		39	0.66		16	16.93	33 91	17.52
	31.5		41	6.32		15	31.18	33.93	17.52
Feb.	1.5		43	12.58		14	45.25	33.95	17.52
	2.5		45	19.35		13	59.12	33.97	17.52
	3.5		47	26.75		13	12.83	34.00	17.52

Ephemeris of Neptune for the last half of the years 1848 *and* 1849. *Apparent places affected with aberration.*

APPARENT PLACE OF NEPTUNE FOR MEAN NOON, GREENWICH.

Date.		Right ascension.			Date.		South declination.		
		°	′	″			°	′	″
1848, July	1	334	37	48.08	1848, July	1	— 11	13	26.65
	2		37	0.83		2		13	46.38
	3		36	12.01		3		14	6.67
	4		35	21.65		4		14	27.52
	5		34	29.77		5		14	48.92
	6		33	36.39		6		15	10.87
	7		32	41.53		7		15	33.36
	8		31	45.22		8		15	56.36
	9		30	47.48		9		16	19.88
	10		29	48.34		10		16	43.91
	11		28	47.84		11		17	8.44
	12		27	45.98		12		17	33.46
	13		26	42.78		13		17	58 97
	14		25	38.24		14		18	24.95
	15		24	32.39		15		18	51.41
	16		23	25.27		16		19	18.32
	17		22	16.89		17		19	45 68
	18		21	7.25		18		20	13.49
	19		19	56.41		19		20	41.75
	20		18	44 40		20		21	10.42
	21		17	31.25		21		21	39.48
	22		16	16.98		22		22	8.94
	23		15	1.61		23		22	38.78
	24		13	45.17		24		23	9 01
	25		12	27.68		25		23	39 61
	26		11	9.16		26		24	10.57
	27		9	49.63		27		24	41.88
	28		8	29.12		28		25	13.52
	29		7	7.68		29		25	45.49
	30		5	45.35		30		26	17.75
	31		4	22.15		31		26	50.35
August	1		2	58.12	August	1		27	23.18
	2		1	33.30		2		27	56.28
	3	334	0	7.72		3		28	29.64
	4	333	58	41.41		4		29	3.26
	5		57	14.40		5		29	37.09
	6		55	46.72		6		30	11.12
	7		54	18.39		7		30	45.37
	8		52	49.47		8		31	19.85
	9		51	19.99		9		31	54.47
	10		49	49.99		10		32	29.25
	11		48	19.54		11		33	4.20

Ephemeris of Neptune—Continued.

APPARENT PLACE OF NEPTUNE FOR MEAN NOON, GREENWICH.

Date.		Right ascension.			Date.		South declination.		
		°	′	″			°	′	″
1848, Aug.	12	333	46	48.64	1848, Aug.	12	— 11	33	39.30
	13		45	17.31		13		34	14.51
	14		43	45.54		14		34	49.84
	15		42	13.37		15		35	25.27
	16		40	40.84		16		36	0.80
	17		39	8.00		17		36	36.40
	18		37	34.90		18		37	12.08
	19		36	1.57		19		37	47.79
	20		34	28.01		20		38	23.54
	21		32	54.29		21		38	59.32
	22		31	20.46		22		39	35.11
	23		29	46.54		23		40	10.92
	24		28	12.56		24		40	46.68
	25		26	38.57		25		41	22.43
	26		25	4.62		26		41	58.13
	27		23	30.73		27		42	33.79
	28		21	56.93		28		43	9.38
	29		20	23.24		29		43	44.87
	30		18	49.70		30		44	20.27
	31		17	16.37		31		44	55.56
Sept.	1		15	43.30	Sept.	1		45	30.73
	2		14	10.51		2		46	5.75
	3		12	38.04		3		46	40.61
	4		11	5.93		4		47	15.30
	5		9	34.22		5		47	49.81
	6		8	2.90		6		48	24.11
	7		6	32.05		7		48	58.21
	8		5	1.68		8		49	32.09
	9		3	31.86		9		50	5.73
	10		2	2.60		10		50	39.13
	11	333	0	33.94		11		51	12.27
	12	332	59	5.91		12		51	45.16
	13		57	38.55		13		52	17.76
	14		56	11.90		14		52	50.07
	15		54	45.97		15		53	22.06
	16		53	20.80		16		53	53.74
	17		51	56.43		17		54	25.09
	18		50	32.90		18		54	56.11
	19		49	10.23		19		55	26.77
	20		47	48.43		20		55	57.07
	21		46	27.56		21		56	27.00
	22		45	7.64		22		56	56.54
	23		43	48.71		23		57	25.68
	24		42	30.80		24		57	54.42

Ephemeris of Neptune—Continued.

APPARENT PLACE OF NEPTUNE FOR MEAN NOON, GREENWICH.

Date.	Right ascension.			Date.	South declination.		
	°	′	″		°	′	″
1848, Sept. 25	332	41	13.94	1848, Sept. 25	— 11	58	22.72
26		39	58.20	26		58	50.59
27		38	43.63	27		59	18.01
28		37	30.24	28	11	59	44.97
29		36	18.05	29	12	0	11.47
30		35	7.09	30		0	37.51
October 1		33	57.38	October 1		1	3.06
2		32	48.94	2		1	28.10
3		31	41.80	3		2	52.63
4		30	35.98	4		2	16.64
5		29	31.48	5		2	40.13
6		28	28.37	6		3	3.06
7		27	26.66	7		3	25.44
8		26	26.36	8		3	47.26
9		25	29.50	9		4	8.54
10		24	30.12	10		4	29.23
11		23	34.23	11		4	49.35
12		22	39.88	12		5	8.91
13		21	47.08	13		5	27.87
14		20	55.87	14		5	46.23
15		20	6.27	15		6	3.99
16		19	18.30	16		6	21.14
17		18	31.97	17		6	37.68
18		17	47.29	18		6	53.60
19		17	4.29	19		7	8.88
20		16	22.98	20		7	23.50
21		15	43.38	21		7	37.46
22		15	5.53	22		7	50.76
23		14	29.44	23		8	3.40
24		13	55.14	24		8	15.40
25		13	22.60	25		8	26.74
26		12	51.87	26		8	37.38
27		12	22.96	27		8	47.32
28		11	55.88	28		8	56.59
29		11	30.65	29		9	5.19
30		11	7.31	30		9	13.09
31		10	45.86	31		9	20.28
Nov. 1		10	26.29	Nov. 1		9	26.74
2		10	8.63	2		9	32.49
3		9	52.88	3		9	37.54
4		9	39.04	4		9	41.88
5		9	27.11	5		9	45.52
6		9	17.11	6		9	48.44

Ephemeris of Neptune—Continued.

APPARENT PLACE OF NEPTUNE FOR MEAN NOON, GREENWICH.

Date.	Right ascension.			Date.	South declination.		
	°	′	″		°	′	″
1848, Nov. 7	332	9	9.01	1848, Nov. 7	— 12	9	50.64
8		9	2.90	8		9	52.12
9		8	58.73	9		9	52.88
10		8	56.51	10		9	52.92
11		8	56.24	11		9	52.24
12		8	57.96	12		9	50.82
13		9	1.64	13		9	48.68
14		9	7.28	14		9	45.82
15		9	14.89	15		9	42.23
16		9	24.48	16		9	37.91
17		9	36.05	17		9	32.86
18		9	49.60	18		9	27.08
19		10	5.12	19		9	20.57
20		10	22.62	20		9	13.32
21		10	42.11	21		9	5.34
22		11	3.57	22		8	56.64
23		11	27.01	23		8	47.21
24		11	52.44	24		8	37.04
25		12	19.88	25		8	26.16
26		12	49.30	26		8	14.57
27		13	20.69	27		8	2.25
28		13	54.04	28		7	49.20
29		14	29.34	29		7	35.44
30		15	6.57	30		7	20.97
Dec. 1		15	45.73	Dec. 1		7	5.79
2		16	26.82	2		6	49.90
3		17	9.82	3		6	33.30
4		17	54.73	4		6	16.02
5		18	41.53	5		5	52.05
6		19	30.22	6		5	39.37
7		20	20.77	7		5	20.01
8		21	13.18	8		4	59.98
9		22	7.43	9		4	39.28
10		23	3.51	10		4	17.91
11		24	1.41	11		3	55.87
12		25	1.12	12		3	33.16
13		26	2.63	13		3	9.79
14		27	5.91	14		2	45.78
15		28	10.96	15		2	21.14
16		29	17.77	16		1	55.85
17		30	26.33	17		1	29.90
18		31	36.62	18		1	3.32
19		32	48.62	19		0	36.11
20		34	2.30	20	— 12	0	8.28

Ephemeris of Neptune—Continued.

APPARENT PLACE OF NEPTUNE FOR MEAN NOON, GREENWICH.

Date.	Right ascension.			Date.	South declination.		
	°	′	″		°	′	″
1848, Dec. 21	332	35	17.65	1848, Dec. 21	— 11	59	39.85
22		36	34.65	22		59	10.81
23		37	53.30	23		58	41.16
24		39	13.55	24		58	10.93
25		40	35.34	25		57	40.07
26		41	58.71	26		57	8.63
27		43	23.64	27		56	36.62
28		44	50.14	28		56	4.03
29		46	18.22	29		55	30.96
30		47	47.86	30		54	57.33
31		49	18.99	31		54	23.16
1849, Jan. 1	332	50	51.62	1849, Jan. 1	— 11	53	48.44
July 1	336	47	30 01	July 1	— 10	27	57.79
2		46	47.17	2		28	16.38
3		46	2.70	3		28	35.55
4		45	16.64	4		28	55.31
5		54	28.99	5		29	15.64
6		53	39.77	6		29	36.55
7		42	49.01	7		29	58.03
8		41	56.74	8		30	20.06
9		41	2.99	9		30	42.66
10		40	7.79	10		31	5.81
11		39	11.16	11		31	29.51
12		38	13.11	12		31	53.73
13		37	13.66	13		32	18.48
14		36	12.85	14		32	43.74
15		35	10 70	15		33	9.49
16		34	7.22	16		33	35.73
17		33	2.40	17		34	2.45
18		31	56.26	18		34	29.64
19		30	48.82	19		34	57.31
20		29	40.13	20		35	25.44
21		28	30.21	21		35	54.02
22		27	19.10	22		36	23.05
23		26	6.84	23		36	52.50
24		24	53.46	24		37	22.34
25		23	38.98	25		37	52.57
26		22	23.43	26		38	23.17
27		21	6.84	27		38	54.15
28		19	49.23	28		39	24.49
29		18	30.62	29		39	57.19
30		17	11.03	30		40	29.24
31		15	50.49	31		41	1.62

Ephemeris of Neptune—Continued.

APPARENT PLACE OF NEPTUNE FOR MEAN NOON, GREENWICH.

Date.	Right ascension.			Date.	South declination.		
	°	′	″		°	′	″
1849, August 1	336	14	29.05	1849, August 1	— 10	41	34.33
2		13	6.74	2		42	7.35
3		11	43.61	3		42	40.65
4		10	19.68	4		43	14.21
5		8	54.97	5		43	48.04
6		7	29.50	6		44	22.13
7		6	3.32	7		44	56.47
8		4	36.45	8		45	31.02
9		3	8.92	9		46	5.77
10		1	40.73	10		46	40.75
11	336	0	11.92	11		47	15.94
12	335	58	42.52	12		47	51.31
13		57	12.62	13		48	26.83
14		55	42.27	14		49	2.51
15		54	11.49	15		49	38.34
16		52	40.28	16		50	14.29
17		51	8.64	17		50	50.34
18		49	36.61	18		51	26.49
19		48	4.25	19		52	2.73
20		46	31.62	20		52	39.05
21		44	58.75	21		53	15.43
22		43	25.67	22		53	51.84
23		41	52.41	23		54	28.27
24		40	19.00	24		55	4.72
25		38	45.49	25		55	41.17
26		37	11.91	26		56	17.61
27		35	38.36	27		56	54.01
28		34	4.82	28		57	30.37
29		32	31.33	29		58	6.67
30		30	57.93	30		58	42.91
31		29	24.65	31		59	19.07
Sept. 1		27	51.50	Sept. 1	— 10	59	55.12
2		26	18.50	2	11	0	31.07
3		24	45.71	3		1	6.91
4		23	13.17	4		1	42.63
5		21	40.92	5		2	18.20
6		20	9.01	6		2	53.59
7		18	37.48	7		3	28.81
8		17	6.34	8		4	3.84
9		15	35.62	9		4	38.66
10		14	5.34	10		5	13.27
11		12	35.57	11		5	47.65
12		11	6.33	12		6	21.79
13		9	37.66	13		6	55.68

Ephemeris of Neptune—Continued.

APPARENT PLACE OF NEPTUNE FOR MEAN NOON, GREENWICH.

Date.	Right ascension.			Date.	South declination.		
	°	′	″		°	′	″
1849, Sept. 14	335	8	9.59	1849, Sept. 14	−11	7	29.32
15		6	42.17	15		8	2.68
16		5	15.43	16		8	35.74
17		3	49.42	17		9	8.49
18		2	24.16	18		9	40.92
19	335	0	59.67	19		10	13.01
20	334	59	36.00	20		10	44.74
21		58	13.21	21		11	16.11
22		56	51.32	22		11	47.11
23		55	30.34	23		12	17.74
24		54	10.29	24		12	47.98
25		52	51.20	25		13	17.81
26		51	33.10	26		13	47.22
27		50	16.04	27		14	16.20
28		49	0.04	28		14	44.74
29		47	45.15	29		15	12.83
30		46	31.44	30		15	40.45
Oct. 1		45	18.96	Oct. 1		16	7.60
2		44	7.66	2		15	34.27
3		42	57.59	3		17	0.47
4		41	48.77	4		17	26.16
5		40	41.22	5		17	51.35
6		39	34.96	6		18	16.02
7		38	30.01	7		18	40.17
8		37	26.39	8		19	3 78
9		36	24.16	9		19	26.82
10		35	23.34	10		19	49.30
11		34	23.94	11		20	11.21
12		33	25.98	12		20	32.54
13		32	29.52	13		20	53.29
14		31	34.58	14		21	13.43
15		30	41.18	15		21	32.97
16		29	49.35	16		21	51.90
17		28	59.12	17		22	10.23
18		28	10.52	18		22	27.95
19		27	23.55	19		22	45.02
20		26	38.23	20		23	1.43
21		25	54.59	21		23	17.21
22		25	12.65	22		23	32.32
23		24	32.42	23		23	46.77
24		23	53.91	24		24	0.54
25		23	17.14	25		24	13.63
26		22	42.14	26		24	26.04
27		22	8.91	27		24	37.78

Ephemeris of Neptune—Continued.

APPARENT PLACE OF NEPTUNE FOR MEAN NOON, GREENWICH.

Date.	Right ascension.			Date.	South declination.		
	°	′	″		°	′	″
1849, Oct. 28	334	21	37.46	1849, Oct. 28	— 11	24	48.84
29		21	7.80	29		24	59.21
30		20	39.94	30		25	8.88
31		20	13.89	31		25	17.86
Nov. 1		19	49.68	Nov. 1		25	26.14
2		19	27.35	2		25	33.71
3		19	6.90	3		25	40.56
4		18	48.34	4		25	46.68
5		18	31.68	5		25	52.07
6		18	16.92	6		25	56.74
7		18	4.07	7		26	0.69
8		17	53.13	8		26	3.92
9		17	44.10	9		26	6.41
10		17	36 97	10		26	8 17
11		17	31.84	11		26	9.20
12		17	28.64	12		26	9.49
13		17	27.38	13		26	9.03
14		17	28.08	14		26	7 83
15		17	30.76	15		26	5.89
16		17	35.39	16		26	3 16
17		17	42.00	17		25	59.71
18		17	50.57	18		25	55.52
19		18	1.12	19		25	50.57
20		18	13.64	20		25	44.87
21		18	28.14	21		25	38.43
22		18	44.61	22		25	31.25
23		19	3.06	23		25	23.32
24		19	23.50	24		25	14.65
25		19	45.90	25		25	5.24
26		20	10.28	26		24	55.09
27		20	36.62	27		24	44.20
28		21	4 95	28		24	32.57
29		21	35.24	29		24	20.22
30		22	7.48	30		24	7.15
Dec. 1		22	41.63	Dec. 1		23	53.35
2		23	17.68	2		23	38.83
3		23	55.65	3		23	23.59
4		24	35.53	4		23	7.63
5		25	17.32	5		22	50.94
6		26	1.01	6		22	33.54
7		26	46.60	7		22	15.44
8		27	34.09	8		21	56.63
9		28	23.46	9		21	37.11

Ephemeris of Neptune—Continued.

APPARENT PLACE OF NEPTUNE FOR MEAN NOON, GREENWICH.

Date.	Right ascension.			Date.	South declination.		
	°	′	″		°	′	″
1849, Dec. 10	334	29	14.69	1849, Dec. 10	— 11	21	16.88
11		30	7.78	11		20	55.97
12		31	2.70	12		20	34.38
13		31	59.45	13		20	12.10
14		32	58.01	14		19	49.14
15		33	58.38	15		19	25.50
16		35	0.54	16		19	1.19
17		36	4.47	17		18	36.22
18		37	10.17	18		18	10.59
19		38	17.62	19		17	44.31
20		39	26.81	20		17	17.37
21		40	37.71	21		16	49.79
22		41	50.29	22		16	21.58
23		42	4.54	23		15	52.75
24		44	20.44	24		15	23.32
25		45	37.95	25		14	53.29
26		46	57.05	26		14	22.66
27		48	17.71	27		13	51.43
28		49	39.90	28		13	19.61
29		51	3.69	29		12	47.20
30		52	29.01	30		12	14.21
31		53	55.85	31		11	40.64
1850, Jan. 1		55	24.22	1850, Jan. 1		11	6.59

The radius vector of Neptune in the following table is rigorous. The logarithm of the distance from the earth may be interpolated from the column for 1847 *with sufficient precision for planetary aberration and parallax, by recollecting that it returns very nearly to the same value in a synodic year of* $367\frac{1}{2}$ *days.*

Month and day.		NEPTUNE'S RADIUS VECTOR.				Logarithm of distance from the earth.
		1846.	1847	1848.	1849.	1847.
January	1	30.01681	30.00430	29.99216	29.98085	1.48689
February	1	.01574	.00325	.99116	.97994	.49071
March	1	.01477	.00230	.99023	.97918	.49093
April	1	.01370	.00126	.98924	.97827	.48768
May	1	.01266	30.00025	.98825	.97734	.48178
June	1	.01160	29.99919	.98730	.97647	.47433
July	1	.01057	.99818	.98638	.97562	.46761
August	1	.00951	.99715	.98543	.97476	.46347
September	1	.00845	.99614	.98449	.97391	.46248
October	1	.00742	99515	.98357	.97308	.46503
November	1	.00636	.99413	.98263	.97223	.47211
December	1	.00534	.99315	.98174	.97142	.47951
		1795				1795.
May	9	30.30430	–	–	–	1.46724

APPENDIX II. TO VOLUME II.

OF THE

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE:

CONTAINING

AN EPHEMERIS OF THE PLANET NEPTUNE

FOR THE YEAR 1850.

BY SEARS C. WALKER, ESQ.

GIDEON & CO., PRINTERS, WASHINGTON, D. C.

SMITHSONIAN INSTITUTION, *April*, 1850.

This Ephemeris of the planet Neptune was prepared for the Nautical Almanac, but appears this year again among the Smithsonian Contributions, by permission of the Hon. WM. BALLARD PRESTON, Secretary of the Navy.

JOSEPH HENRY,
Secretary of the Smithsonian Institution.

CHARLES HENRY DAVIS, LIEUT.,
Superintendent of the Nautical Almanac.

LETTER

FROM

LIEUTENANT C. H. DAVIS,

SUPERINTENDENT OF THE NAUTICAL ALMANAC,

TO

JOSEPH HENRY, LL.D.,

SECRETARY OF THE SMITHSONIAN INSTITUTION.

Sir: With the authority of the Hon. Secretary of the Navy, I have the pleasure to submit to you for publication the Ephemeris of the planet Neptune, for the year 1850, prepared for the Nautical Almanac by Sears C. Walker, Esq. This is a continuation of the Ephemeris of 1849, which appeared in Appendix I to Vol. II, of the Smithsonian Contributions; being based on the same theory, elements, formulæ, and constants, viz., Prof. Peirce's theory, and Mr. Walker's elements, as originally published in the Proceedings of the American Academy for April 4, 1848.

In his introduction to the Ephemeris of 1848, Mr. Walker remarked, "Prof. Peirce's new theory of Uranus may now be considered as complete. That of Neptune can hardly be expected to make further advances till another opposition is observed." And in 1849, the opposition of 1848 having been in the mean time observed and discussed, without indicating any sensible correction, he added, "I have accordingly not attempted any change in the elements used as the basis of the Ephemeris of 1849."

The theory and elements have now been submitted to the test of a second opposition, that of 1849, and Mr. Walker still finds that no sensible correction is required in the basis of the Ephemeris for 1850. This result is as gratifying as it is unexpected. It evinces the great care bestowed by Prof. Peirce upon his second essay to perfect the theory of Neptune, and the remarkable accuracy with which the elements of Mr. Walker were determined, from data that could never have been regarded as sufficient to furnish a complete orbit.

As this subject is one of general interest, and as it holds a prominent place in the history of astronomical science in America, I will make no apology for entering here more fully into its consideration.

The venerable and eminent astronomer and mathematician, Bernhard von Lindenau, in a recent paper, entitled "Contribution to the history of the discovery of Neptune," after stating the condition in which this very peculiar question was left by the discoverers, Le Verrier and Adams, expresses his expectation that it will soon be brought to a satisfactory conclusion by a new investigation on the part of these geometers.

"It is to be expected," he observes, "that the former results of the computations will undergo a material change; for, if we apply to the perturbations of Neptune by Uranus, computed by Peirce, the proposition of La Place, controlling the equations of the perturbations of long period, viz., that the reciprocal perturbations of two planets are to each other as the products of the masses by the square roots of the semi-axis major, (Méc. Cél., Vol. III, p. 147,) we shall obtain for Uranus values very different from those on which the investigations of Le Verrier and Adams are based. If the question was in the beginning to solve the inverse problem of perturbations, we must now come back to the direct problem, which is, to determine by means of the perturbations of Uranus by Jupiter, Saturn, and Neptune, taken in connection with the observations of Uranus from 1690 to 1848, an orbit of Uranus which will represent in the best manner the whole of the observations."*

After finishing his paper, however, and while waiting to see the subject brought to a satisfactory termination by a new investigation on the part of Le Verrier or Adams, Lindenau received ***the new and important work*** (such are his words) on Neptune, contained in Vol. II. of the Smithsonian Contributions to Knowledge, by the American astronomer, Walker, whose first elliptic elements he had previously communicated.

He was thus led to append a supplement to the "Contribution," in which he gives the more essential points of the further development of the theory of Neptune and Uranus, and speaks of the labors of Mr. Walker in the following terms: "By using all the observations made in the old and new world in the years 1795, 1846–'47,–'48,† (amounting to more than a thousand,) and taking into account the perturbations of Neptune by Jupiter, Saturn, and Uranus, computed by Peirce, Mr. Walker obtained elements which represent not only the two observations of Lalande, but also all the recent ones within the limits of a few seconds. [Tenths of seconds of arc would have been more correct.] So that the Ephemeris computed by him from those elements for the periods from May 8 to 11, 1795, and from August, 1846, to January, 1850, is perfectly sufficient as well for finding the planet as for the comparison of the observed place."

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* This and the following extracts from Lindenau's paper are taken from a translation made by Mr. François de Pourtalès. The original is published by Prof. Schumacher in his supplement to the Astronomical Notices.

† This should be omitted, Mr. Walker having used only those of 1795, 1846, and 1847.

To this testimony, coming from too high a source to be overlooked or disregarded, it may be added as an illustration of the success attending the labors of American astronomers in this new and interesting field of research, that if, during the historical periods of the observations, the Neptune of prediction, and that of the Heavens, were conceived to form a double star, they would have such close proximity that no telescope could separate them, even if it possessed sufficient power to detect their duplicity. There is one circumstance which, indeed, is not to be forgotten; and that is, the great distance of the planet, which prevents the small errors of the best theory of the earth (the point of view of the Ephemeris) from sensibly affecting its projected place in the Heavens, the impressed errors of the latter being only a thirtieth part of the former.

The experience of 1848 and 1849 shows, that for the case of a very remote planet, it is possible, by the exercise of proper care, to compute an ephemeris in advance, that shall surpass the whole season's work of a single observatory in its close agreement with the average work of all. Mr. Walker's comparisons of the Ephemeris with observations for these years will serve as a justification of this remark. The meridian observations only have been used, with the exception of Liverpool in 1849.

Observatory.	Nation.	Astronomer.	Obs.—Eph., for the opposition.				Obs.—Eph., for the quadrature.			
			For R. A. in arc. $\Delta\alpha$	No. of Obs.	For Dec. $\Delta\delta$	No. of Obs.	For R. A. in arc. $\Delta\alpha$	No. of Obs.	For Dec. $\Delta\delta$	No. of Obs.
1848.			$''$		$''$		$''$		$''$	
Altona	Denmark	Petersen	— 1.20	10	+ 0.41	11	— 0.56	5	— 0.35	5
Athens	Greece	Bouris	+ 0.12	15	+ 0.61	15	— 2.23*	41	+ 1.94*	41
Cambridge	England	Challis	— 0.89	24	+ 1.97	23				
Copenhagen	Denmark	Sievers	+ 2.52	4	- -	- -	+ 0.29	11		
Durham	England	Thompson	— 0.95	4	— 0.46	3	— 0.99	5	+ 1.40	5
Hamburg	Germany	Rümker	— 0.95	26	— 1.29	25	— 0.80	10	— 1.66	10
Königsberg	E. Prussia	Busch	+ 0.81	6	— 1.01	6	+ 0.33	3	— 0.76	3
Markree	Ireland	Graham	— 1.00	6	— 0.46	6	— 0.07	23	+ 0.19	23
Petersburg	Russia	Sawitsch	— 1.22	8	+ 1.40	8	— 0.32	5	— 0.89	4
Average for 1848			— 0.66	103	+ 0.28	97	— 0.56	103	+ 0.28	91
1849.										
Altona	Denmark	Schumacher	- -	- -	- -	- -	— 1.46	10	— 1.28	10
Hamburg	Germany	Rumker	— 0.60	17	— 0.55	17	+ 0.37	18	— 0.67	20
Liverpool	England	Hartnup	— 1.45	3	+ 1.59	3	— 1.23	11	— 0.34	11
Average for 1849			— 0.74	20	— 0.23	20	— 0.55	39	— 0.73	41

* Used with a weight of 20.

Mr. Walker has also furnished the comparison of the ephemeris with the normal places, derived from all the observations yet received.

DATE.	OBSERVATION—EPHEMERIS.			
	For R. A. in arc. $\Delta\alpha$	No. of Obs.	For Declination. $\Delta\delta$	No. of Obs.
1795, May 9	$+ 0''.20$	2	$+ 0''.55$	2
*1845, October 25	+ 3.40	1	+ 2.38	1
1846, September 26	— 0.21	160	+ 0.55	144
November 6	+ 0.11	343	+ 0.62	297
December 31	+ 0.95	90	+ 0.92	80
1847, April 6	+ 0.42	15	— 0.18	16
August 22	— 0.64	76	+ 0.19	71
November 8	— 0.96	46	+ 0.77	51
December 18	— 0.44	18	+ 0.89	18
1848, August 24	— 0.66	103	+ 0.28	97
November 10	— 0.56	103	+ 0.28	91
1849, August 26	— 0.74	20	— 0.23	20
November 12	— 0.55	39	— 0.73	41

Having, in the first quotation from Lindenau's paper, introduced the mention of the theory of Uranus, it may be well to add a word on that subject.

Professor Peirce, in a communication to the American Academy, made on the 4th of April, 1848, announced that he had completed his investigation into the action of Neptune upon Uranus, from which it appeared that, with the mass of Neptune deduced from Mr. Bond's observations of Lassell's satellite, the theory of Uranus was then perfect, and that the motions of this planet did not indicate that there was any other unknown source of perturbation.

But there is "considerable uncertainty in the determination of the mass of Uranus, which still fluctuates, notwithstanding the most recent observations. It is so difficult to make accurate measures of the elongations of the satellites, on account of their faintness, and of their being seen only under very favorable circumstances of position and atmosphere, that the value of the mass derived from the most recent observations by Lassell and Herschel, of two interior satellites, varies between $\frac{1}{15480}$ and $\frac{1}{26860}$. Mr. Adams, for whose labors this element is of great importance, finds, by a new reduction of the observations of Lassell, $\frac{1}{20897}$, and of those of Herschel, $\frac{1}{21165}$, and thinks accordingly, that a mass of $\frac{1}{21000}$ would approach nearest to the truth." (Lindenau, Suppl.)

Professor Peirce, in his second approximation to the theory of Neptune, adopted the mass of Uranus taken from Lamont's determination by the observation of the satellites. But the mass remains to be determined anew, as he has already stated, by a study of the perturbations produced by Uranus in the orbits

* Lamont's Observation in his Zones, discovered by Mr. Hind.

of Jupiter and Saturn; and this investigation, involving a vast amount of labor, will run through the historical period of that planet. There are recent indications that such a work has been begun by Adams; if, however, it should not be accomplished on the other side of the water, it will be undertaken by Professor Peirce at his earliest leisure.

I will cite, in conclusion, a passage from Lindenau, relating to the discovery of Neptune, expressing an opinion, entertained, as I believe, by the best authorities on the continent of Europe and in this country: "I cannot so well agree with the view of the President of the Astronomical Society, when he treats the merits of Le Verrier and Adams, in the discovery of Neptune, as fraternal; for, leaving out of the question the peculiarities in their modes of proceeding, there is still an important difference in the fact, that the one came out boldly and quickly with his presumed discovery, while the other only communicated the similar result of his labors confidentially to a few friends. The fact that the French, English, Prussian, and German astronomers had no great confidence in Le Verrier's theoretical place of Neptune, is shown by the delay in searching for it; and Challis, who had first undertaken the search in a systematic manner, says: 'I confess that in the whole of the undertaking I had too little confidence in the indications of theory, though, perhaps, not less than most other astronomers might have felt under the same circumstances.' (Mem. of the Astro. Soc., Vol. XIV, p. 224.")

Very respectfully, your obedient servant,

CHARLES HENRY DAVIS.

1850. April 5th.

EPHEMERIS OF NEPTUNE FOR 1850.

APPARENT PLACE OF NEPTUNE FOR MEAN NOON, GREENWICH.

Date.	Right Ascension of Neptune.			South Declination of Neptune.			Date.	Right Ascension of Neptune.			South Declination of Neptune.		
1850.	°	′	″	°	′	″	1850.	°	′	″	°	′	″
Jan. 1	334	55	24.22	— 11	11	6.59	July 31	338	26	38.63	— 9	54	18.37
9	335	8	1.10	— 11	6	15.31	August 1	338	25	19.95	— 9	54	50.77
17	335	22	0.95	— 11	0	52.87	2	338	24	0.31	— 9	55	23.52
25	335	37	9.41	— 10	55	4.82	3	338	22	39.74	— 9	55	56.61
Feb. 2	335	53	12.06	— 10	48	56.37	4	338	21	18.27	— 9	56	30.02
10	336	9	54.89	— 10	42	33.41	5	338	19	55.95	— 9	57	3.74
18	336	27	2.76	— 10	36	1.07	6	338	18	32.80	— 9	57	37.74
26	336	44	19.56	— 10	29	25.82	7	338	17	8.83	— 9	58	12.02
March 6	337	1	30.59	— 10	22	53.31	8	338	15	44.08	— 9	58	46.58
14	337	18	21.76	— 10	16	28.99	9	338	14	18.60	— 9	59	21.39
22	337	34	36.98	— 10	10	19.00	10	338	12	52.42	— 9	59	56.43
30	337	50	3.38	— 10	4	28.98	11	338	11	25.56	— 10	0	31.68
April 7	338	4	28.36	— 9	59	3 54	12	338	9	58.05	— 10	1	7.16
15	338	17	39.73	— 9	54	7.15	13	338	8	29.91	— 10	1	42.85
23	338	29	25.88	— 9	49	44.99	14	338	7	1.19	— 10	2	18.72
May 1	338	39	38.07	— 9	46	0.32	15	338	5	31.95	— 10	2	54.76
9	338	48	8.43	— 9	42	56.30	16	338	4	2.24	— 10	3	30.95
17	338	54	49.69	— 9	40	35.76	17	338	2	32.10	— 10	4	7.29
25	338	59	37.00	— 9	39	0.54	18	338	1	1.54	— 10	4	43.77
June 2	339	2	27.85	— 9	38	11.47	19	337	59	30.56	— 10	5	20.35
10	339	3	20.55	— 9	38	9.16	20	337	57	59.18	— 10	5	57.03
18	339	2	15.42	— 9	38	52.99	21	337	56	27.43	— 10	6	33.81
26	338	59	16.11	— 9	40	21.52	22	337	54	55.37	— 10	7	10.67
30	338	57	5.17	— 9	41	21.79	23	337	53	23.05	— 10	7	47.59
July 1	338	56	28.31	— 9	41	38.48	24	337	51	50.49	— 10	8	24.56
2	338	55	49.80	— 9	41	55.80	25	337	50	17.75	— 10	9	1.56
3	338	55	9.66	— 9	42	13.76	26	337	48	44.88	— 10	9	38.58
4	338	54	27.90	— 9	42	32.34	27	337	47	11.92	— 10	10	15.61
5	338	53	44.51	— 9	42	51.55	28	337	45	38.89	— 10	10	52.64
6	338	52	59.51	— 9	43	11.37	29	337	44	5.80	— 10	11	29.65
7	338	52	12.92	— 9	43	31 78	30	337	42	32.67	— 10	12	6.64
8	338	51	24.75	— 9	43	52.78	31	337	40	59.52	— 10	12	43.59
9	338	50	35.03	— 9	44	14.36	Sept. 1	337	39	26.39	— 10	13	20.49
10	338	49	43.80	— 9	44	36.51	2	337	37	53.32	— 10	13	57.31
11	338	48	51.08	— 9	44	59.23	3	337	36	20.36	— 10	14	34.02
12	338	47	56.88	— 9	45	22.51	4	337	34	47.55	— 10	15	10.64
13	338	47	1.25	— 9	45	46.35	5	337	33	14.93	— 10	15	47.17
14	338	46	4.19	— 9	46	10.75	6	337	31	42.55	— 10	16	23.56
15	338	45	5.73	— 9	46	35.68	7	337	30	10.45	— 10	16	59.79
16	338	44	5.90	— 9	47	1.12	8	337	28	38.68	— 10	17	35.85
17	338	43	4.73	— 9	47	27.07	9	337	27	7.27	— 10	18	11.74
18	338	42	2.23	— 9	47	53.51	10	337	25	36.28	— 10	18	47.45
19	338	40	58.39	— 9	48	20.44	11	337	24	5.60	— 10	19	22.96
20	338	39	53.24	— 9	48	47.85	12	337	22	35.41	— 10	19	58.26
21	338	38	46.83	— 9	49	15.73	13	337	21	5.71	— 10	20	33.31
22	338	37	39.17	— 9	49	44.08	14	337	19	36.55	— 10	21	8.09
23	338	36	30.29	— 9	50	12.90	15	337	18	7.96	— 10	21	42.62
24	338	35	20.23	— 9	50	42.17	16	337	16	39.97	— 10	22	16.89
25	338	34	9.00	— 9	51	11.87	17	337	15	12.62	— 10	22	50 89
26	338	32	56.64	— 9	51	41.97	18	337	13	45.92	— 10	23	24.59
27	338	31	43.18	— 9	52	12.48	19	337	12	19.95	— 10	23	57.98
28	338	30	28.63	— 9	52	43.38	20	337	10	54.71	— 10	24	31.06
29	338	29	13.00	— 9	53	14.66	21	337	9	30.23	— 10	25	3.80
30	338	27	56.32	— 9	53	46.33	22	337	8	6.53	— 10	25	36.18

Ephemeris of Neptune—Continued.

APPARENT PLACE OF NEPTUNE FOR MEAN NOON, GREENWICH.

Date.	Right Ascension of Neptune.			South Declination of Neptune.			Date.	Right Ascension of Neptune.			South Declination of Neptune.		
1850.	°	′	″	°	′	″	1850.	°	′	″	°	′	″
Sept. 23	337	6	43.65	— 10	26	8.22	Nov. 13	336	25	31.97	— 10	41	27.62
24	337	5	21.63	— 10	26	39.89	14	336	25	27.86	— 10	41	28.14
25	337	4	0.51	— 10	27	11.19	15	336	25	25.70	— 10	41	27.90
26	337	2	40.30	— 10	27	42.10	16	336	25	25.50	— 10	41	26.90
27	337	1	20.99	— 10	28	12.60	17	336	25	27.24	— 10	41	25.14
28	337	0	2.66	— 10	28	42.68	18	336	25	30.93	— 10	41	22.62
29	336	58	45.35	— 10	29	12.33	19	336	25	36.54	— 10	41	19.36
30	336	57	29.07	— 10	29	41.54	20	336	25	44.10	— 10	41	15.34
Oct. 1	336	56	13.87	— 10	30	10.30	21	336	25	53.64	— 10	41	10.55
2	336	54	59.80	— 10	30	38.59	22	336	26	5.14	— 10	41	5.01
3	336	53	46.96	— 10	31	6.41	23	336	26	18.59	— 10	40	58.72
4	336	52	35.27	— 10	31	33.75	24	336	26	34.01	— 10	40	51.67
5	336	51	24.75	— 10	32	0.60	25	336	26	51.40	— 10	40	43.86
6	336	50	15.42	— 10	32	26.94	26	336	27	10.74	— 10	40	35.30
7	336	49	7.36	— 10	32	52.78	27	336	27	32.03	— 10	40	25.99
8	336	48	0.62	— 10	33	18.09	28	336	27	55.27	— 10	40	15.92
9	336	46	55.23	— 10	33	42.84	29	336	28	20.49	— 10	40	5.10
10	336	45	51.22	— 10	34	7.04	30	336	28	47.67	— 10	39	53.52
11	336	44	48.57	— 10	34	30.68	Dec. 1	336	29	16.80	— 10	39	41.20
12	336	43	47.31	— 10	34	53.75	2	336	29	47.89	— 10	39	28.14
13	336	42	47.48	— 10	35	16.23	3	336	30	20.91	— 10	39	14.33
14	336	41	49.11	— 10	35	38.13	4	336	30	55.86	— 10	38	59.77
15	336	40	52.21	— 10	35	59.43	5	336	31	32.75	— 10	38	44.46
16	336	39	56.79	— 10	36	20.12	6	336	32	11.56	— 10	38	28.43
17	336	39	2.88	— 10	36	40.19	7	336	32	52.28	— 10	38	11.66
18	366	38	10.51	— 10	36	59.65	8	336	33	34.90	— 10	37	54.16
19	366	37	19.73	— 10	37	18.50	9	336	34	19.42	— 10	37	35.94
20	336	36	30.54	— 10	37	36.73	10	336	35	5.82	— 10	37	16.99
21	336	35	42.96	— 10	37	54.31	11	336	35	54.11	— 10	36	57.32
22	336	34	57.01	— 10	38	11.23	12	336	36	44.24	— 10	36	36.94
23	436	34	12.71	— 10	38	27.49	13	336	37	36.23	— 10	36	15.87
24	336	33	30.07	— 10	38	43.09	14	336	38	30.02	— 10	35	54.10
25	336	32	49.09	— 10	38	58.04	15	336	39	25.62	— 10	35	31.64
26	336	32	9.81	— 10	39	12.31	16	336	40	23.06	— 10	35	8.49
27	336	31	32.25	— 10	39	25.90	17	336	41	22.28	— 10	34	44.65
28	336	30	56.45	— 10	39	38.80	18	336	42	23.29	— 10	34	20.12
29	336	30	22.39	— 10	39	51.01	19	336	43	26.07	— 10	33	54.93
30	336	29	50.09	— 10	40	2.54	20	336	44	30.50	— 10	33	29.08
31	336	29	19.57	— 10	40	13.36	21	336	45	36.68	— 10	33	2.57
Nov. 1	336	28	50.82	— 10	40	23.47	22	336	46	44.58	— 10	32	35.40
2	336	28	23.88	— 10	40	32.86	23	336	47	54.27	— 10	32	7.57
3	336	27	58.79	— 10	40	41.52	24	336	49	5.63	— 10	31	39.10
4	336	27	35.56	— 10	40	49.46	25	336	50	18.66	— 10	31	10.00
5	336	27	14.20	— 10	40	56.67	26	336	51	33.36	— 10	30	40.29
6	336	26	54.73	— 10	41	3.13	27	336	52	49.67	— 10	30	9.96
7	336	26	37.17	— 10	41	8.85	28	336	54	7.62	— 10	29	39.01
8	336	26	21.50	— 10	41	13.83	29	336	55	27.08	— 10	29	7.45
9	336	26	7.74	— 10	41	18.08	30	336	56	48.14	— 10	28	35.29
10	336	25	55.90	— 10	41	21.59	31	336	58	10.79	— 10	28	2.54
11	336	25	45.98	— 10	41	24.34	1851.						
12	336	25	38.00	— 10	41	26.35	Jan. 1	336	59	34.97	— 10	27	29.17

Date 1850.		Radius Vector.	Heliocentric co-ordinates referred to the apparent equinox and equator.			Logarithm of the distance from the Earth.
		r	x	y	z	Log. Δ
January	1	29.97053	+ 26.97693	— 11.82129	— 5.544177	1.4852562
	9	.97038	26.98776	.80002	.535722	.4867189
	17	.97017	26.99856	.77872	.527269	.4879855
	25	.96996	27.00933	.75743	.518818	.4890324
February	2	.96976	.02008	.73614	.510366	.4898460
	10	.96955	.03081	.71486	.501916	.4904138
	18	.96934	.04151	.69358	.493467	.4907257
	26	.96913	.05219	.67230	.485018	.4907786
March	6	.96892	.06284	.65102	.476567	.4905744
	14	.96871	.07348	.62973	.468111	.4901181
	22	.96850	.08409	.60844	.459648	.4894156
	30	.96830	.09469	.58713	.451181	.4884792
April	7	.96809	.10528	.56582	.442708	.4873295
	15	.96788	.11584	.54450	.434227	.4859821
	23	.96767	.12637	.52317	.425740	.4844612
May	1	.96747	.13690	.50184	.417244	.4827933
	9	.96727	.14741	.48048	.408739	.4810050
	17	.96706	.15791	.45909	.400223	.4791266
	25	.96686	.16841	.43767	.391697	.4771922
June	2	.96666	.17889	.41624	.383162	.4752353
	10	.96645	.18935	.39480	.374623	.4732881
	18	.96625	.19980	.37335	.366081	.4713911
	26	.96605	.21023	.35190	.357537	.4695771
July	4	.96585	.22063	.33044	.348994	.4678793
	12	.96565	.23101	.30898	.340454	.4663326
	20	.96546	.24137	.28750	.331913	.4649689
	28	.96526	.25171	.26603	.323375	.4638154
August	5	.96506	.26203	.24453	.314838	.4628966
	13	.96486	.27233	.22304	.306300	.4622325
	21	.96466	.28260	.20156	.297762	.4618404
	29	.96446	.29284	.18009	.289223	.4617277
September	6	.96426	.30306	.15862	.280683	.4618990
	14	.96407	.31326	.13715	.272138	.4623539
	22	.96388	.32344	.11568	.263587	.4630824
	30	.96368	.33360	.09420	.255032	.4640698
October	8	.96349	.34374	.07271	.246471	.4652965
	16	.96330	.35387	.05120	.237904	.4667382
	24	.96310	.36399	.02969	.229329	.4683635
November	1	.96291	.37409	11.00817	.220744	.4701396
	9	.96272	.38418	10.98663	.212148	.4720315
	17	.96253	.39425	.96504	.203542	.4739974
	25	.96234	.40430	.94343	.194931	.4760012
December	3	.96215	.41434	.92181	.186315	.4780031
	11	.96196	.42437	.90019	.177693	.4799638
	19	.96178	.43439	.87855	.169067	.4818449
	27	.96159	.44440	.85690	.160442	.4836138
	35	.96141	.45439	.83525	.151819	.4852387

APPENDIX III. TO VOLUME II.

OF THE

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE;

CONTAINING

AN EPHEMERIS OF THE PLANET NEPTUNE

FOR THE YEAR 1851.

BY SEARS C. WALKER, ESQ.

Gideon & Co., Printers, Washington, D. C.

Smithsonian Institution, *December*, 1850.

This Ephemeris of the Planet Neptune for the year 1851, prepared for the Nautical Almanac, appears in the Smithsonian Contributions, by authority of the Hon. Wm. A. Graham, Secretary of the Navy.

Signed, JOSEPH HENRY,
Secretary of the Smithsonian Institution.

CHARLES HENRY DAVIS, Lieut.,
Superintendent of the Nautical Almanac.

LETTER

FROM

LIEUTENANT C. H. DAVIS,

SUPERINTENDENT OF THE NAUTICAL ALMANAC,

TO

JOSEPH HENRY, LLD.,

SECRETARY OF THE SMITHSONIAN INSTITUTION.

SIR: With the permission of the Hon. Secretary of the Navy, I have the pleasure to forward to you for publication Mr. Walker's Ephemeris of the Planet Neptune for 1851, prepared at my request for the Nautical Almanac.

The comparison of the Ephemeris of 1850 with observations confirms Mr. Walker's experience of 1848 and 1849, showing that no change can be made in the basis of the Ephemeris for 1851. The latter, therefore, is an extension merely of that of 1850 by Mr. Walker's elements(1) and Professor Peirce's theory.(2)

The numerical values of the perturbations of Neptune's elliptical true longitude and radius vector, are given by Professor Peirce up to the date of January 1, 1851, as computed from the primitive formulæ for the inequalities. They have been extended by Mr. Walker to January 1, 1854, by using the tables in their modified form, as follows:(3)

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(1) Proceedings of the American Academy for April 4, 1848.

(2) Ibid, December 7, 1847.

(3) See page 9th of Prof. Peirce's Memoir, ibid. On page 12th, in the first line of the value of $\mathcal{A}$, for 211° read 221°; also, in the first line for the value of B, for -0.00066 read $+0.00127$.

PERTURBATIONS OF NEPTUNE'S TRUE LONGITUDE AND RADIUS VECTOR, TO BE APPLIED ACCORDING TO THEIR SIGN TO THE ELLIPTIC VALUES.

	$\delta v \,♆$	$\delta r \,♆$
	$''$	
1851, January 1,	— 12.64	+ 0.01308
" April 1,	— 15.08	+ 0.01333
" July 1,	— 17.31	+ 0.01363
" October 1,	— 19.20	+ 0.01398
1852, January 1,	— 20.75	+ 0.01438
" April 1,	— 21.94	+ 0.01479
" July 1,	— 22.80	+ 0.01524
" October 1,	— 23.13	+ 0.01569
1853, January 1,	— 23.01	+ 0.01616
" April 1,	— 22.56	+ 0.01663
" July 1,	— 21.57	+ 0.01708
" October 1,	— 20.09	+ 0.01753
1854, January 1,	— 18.17	+ 0.01793

Very respectfully,

Your obedient servant,

CHARLES HENRY DAVIS.

EPHEMERIS OF NEPTUNE FOR 1851 FOR MEAN NOON, WASHINGTON.

MEAN NOON, WASHINGTON.

Date.	Neptune's Right Ascension.			Neptune's Declination.			Date.	Neptune's Right Ascension.			Neptune's Declination.		
1851.	°	′	″	°	′	″	1851.	°	′	″	°	′	″
Jan. 1	336	59	53.34	— 10	27	21.94	Feb. 24	338	42	24.31	— 9	47	13.21
2	337	1	19.38	— 10	26	47.86	25	338	44	33.40	— 9	46	22.96
3	337	2	46.91	— 10	26	13.22	26	338	46	42.50	— 9	45	32.73
4	337	4	15.92	— 10	25	38.01	27	338	48	51.59	— 9	44	42.52
5	337	5	46.39	— 10	25	2.25	28	338	51	0.63	— 9	43	52.34
6	337	7	18.29	— 10	24	25.96	Mar. 1	338	53	9.59	— 9	43	2.20
7	337	8	51.59	— 10	23	49.14	2	338	55	18.45	— 9	42	12.13
8	337	10	26.26	— 10	23	11.78	3	338	57	27.15	— 9	41	22.11
9	337	12	2.29	— 10	22	33.94	4	338	59	35.68	— 9	40	32.18
10	337	13	39.65	— 10	21	55.57	5	339	1	44.00	— 9	39	42.32
11	337	15	18.31	— 10	21	16.70	6	339	3	52.10	— 9	38	52.58
12	337	16	58.25	— 10	20	37.36	7	339	5	59.94	— 9	38	2.95
13	337	18	39.42	— 10	19	57.56	8	339	8	7.49	— 9	37	13.45
14	337	20	21.80	— 10	19	17.29	9	339	10	14.74	— 9	36	24.08
15	337	22	5.39	— 10	18	36.56	10	339	12	21.62	— 9	35	34.88
16	337	23	50.16	— 10	17	55.39	11	339	14	28.12	— 9	34	45.83
17	337	25	36.07	— 10	17	13.79	12	339	16	34.23	— 9	33	56.95
18	337	27	23.11	— 10	16	31.75	13	339	18	39.90	— 9	33	8.25
19	337	29	11.24	— 10	15	49.30	14	339	20	45.12	— 9	32	19.75
20	337	31	0.46	— 10	15	6.44	15	339	22	49.86	— 9	31	31.45
21	337	32	50.72	— 10	14	23.19	16	339	24	54.09	— 9	30	43.36
22	337	34	42.00	— 10	13	39.55	17	339	26	57.78	— 9	29	55.49
23	337	36	34.26	— 10	12	55.52	18	339	29	0.91	— 9	29	7.86
24	337	38	27.52	— 10	12	11.12	19	339	31	3.45	— 9	28	20.47
25	337	40	21.73	— 10	11	26.37	20	339	33	5.38	— 9	27	33.34
26	337	42	16.86	— 10	10	41.27	21	339	35	6.66	— 9	26	46.48
27	337	44	12.88	— 10	9	55.83	22	339	37	7.29	— 9	25	59.89
28	337	46	9.76	— 10	9	10.06	23	339	39	7.22	— 9	25	13.58
29	337	48	7.49	— 10	8	23.97	24	339	41	6.43	— 9	24	27.57
30	337	50	6.06	— 10	7	37.58	25	339	43	4.89	— 9	23	41.87
31	337	52	5.39	— 10	6	50.90	26	339	45	2.61	— 9	22	56.49
Feb. 1	337	54	5.47	— 10	6	3.94	27	339	46	59.51	— 9	22	11.43
2	337	56	6.27	— 10	5	16.71	28	339	48	55.59	— 9	21	26.71
3	337	58	7.76	— 10	4	29.23	29	339	50	50.81	— 9	20	42.35
4	338	0	9.91	— 10	3	41.50	30	339	52	45.14	— 9	19	58.35
5	338	2	12.68	— 10	2	53.53	31	339	54	38.57	— 9	19	14.72
6	338	4	16.03	— 10	2	5.34	April 1	339	56	31.06	— 9	18	31.48
7	338	6	19.94	— 10	1	16.94	2	339	58	22.62	— 9	17	48.62
8	338	8	24.38	— 10	0	28.34	3	340	0	13.09	— 9	17	6.18
9	338	10	29.33	— 9	59	39.56	4	340	2	2.58	— 9	16	24.15
10	338	12	34.75	— 9	58	50.60	5	340	3	51.05	— 9	15	42.54
11	338	14	40.62	— 9	58	1.48	6	340	5	38.46	— 9	15	1.37
12	338	16	46.91	— 9	57	12.21	7	340	7	24.78	— 9	14	20.64
13	338	18	53.58	— 9	56	22.79	8	340	9	10.00	— 9	13	40.37
14	338	21	0.60	— 9	55	33.26	9	340	10	54.10	— 9	13	0.55
15	338	23	7.95	— 9	54	43.60	10	340	12	37.07	— 9	12	21.20
16	338	25	15.60	— 9	53	53.84	11	340	14	18.88	— 9	11	42.33
17	338	27	23.53	— 9	53	3.98	12	340	15	59.51	— 9	11	3.95
18	338	29	31.70	— 9	52	14.04	13	340	17	38.94	— 9	10	26.06
19	338	31	40.09	— 9	51	24.02	14	340	19	17.14	— 9	9	48.66
20	338	33	48.67	— 9	50	33.94	15	340	20	54.11	— 9	9	11.77
21	338	35	57.41	— 9	49	43.81	16	340	22	29.82	— 9	8	35.40
22	338	38	6.28	— 9	48	53.64	17	340	24	4.25	— 9	7	59.56
23	338	40	15.26	— 9	48	3.44	18	340	25	37.38	— 9	7	24.24

Ephemeris of Neptune—Continued.

MEAN NOON, WASHINGTON.

Date.	Neptune's Right Ascension.			Neptune's Declination.				Date.	Neptune's Right Ascension.			Neptune's Declination.			
1851.	°	′	″		°	′	″	1851.	°	′	″		°	′	″
April 19	340	27	9.19	—	9	6	49.46	June 12	341	10	6.01	—	8	51	39.73
20	340	28	39.67	—	9	6	15.23	13	341	10	4.95	—	8	51	42.59
21	340	30	8.79	—	9	5	41.56	14	341	10	2.08	—	8	51	46.17
22	340	31	36.53	—	9	5	8.44	15	341	9	57.41	—	8	51	50.47
23	340	33	2.87	—	9	4	35.90	16	341	9	50.93	—	8	51	55.49
24	340	34	27.80	—	9	4	3.93	17	341	9	42.64	—	8	52	1.23
25	340	35	51.29	—	9	3	32.55	18	341	9	32.55	—	8	52	7.70
26	340	37	13.32	—	9	3	1.76	19	341	9	20.66	—	8	52	14.88
27	340	38	33.89	—	9	2	31.59	20	341	9	6.98	—	8	52	22.76
28	340	39	52.96	—	9	2	2.02	21	341	8	51.52	—	8	52	31.36
29	340	41	10.52	—	9	1	33.06	22	341	8	34.27	—	8	52	40.68
30	340	42	26.55	—	9	1	4.73	23	341	8	15.25	—	8	52	50.71
May 1	340	43	41.02	—	9	0	37.03	24	341	7	54.46	—	8	53	1.43
2	340	44	53.93	—	9	0	9.97	25	341	7	31.92	—	8	53	12.84
3	340	46	5.26	—	8	59	43.55	26	341	7	7.62	—	8	53	24.95
4	340	47	15.00	—	8	59	17.78	27	341	6	41.58	—	8	53	37.74
5	340	48	23.12	—	8	58	52.69	28	341	6	13.82	—	8	53	51.21
6	340	49	29.62	—	8	58	28.25	29	341	5	44.33	—	8	54	5.35
7	340	50	34.49	—	8	58	4.47	30	341	5	13.12	—	8	54	20.18
8	340	51	37.72	—	8	57	41.36	July 1	341	4	40.22	—	8	54	35.67
9	340	52	39.29	—	8	57	18.93	2	341	4	5.65	—	8	54	51.82
10	340	53	39.19	—	8	56	57.17	3	341	3	29.42	—	8	55	8.61
11	340	54	37.42	—	8	56	36.09	4	341	2	51.54	—	8	55	26.07
12	340	55	33.97	—	8	56	15.70	5	341	2	12.03	—	8	55	44.13
13	340	56	28.83	—	8	55	55.99	6	341	1	30.91	—	8	56	2.83
14	340	57	21.99	—	8	55	36.98	7	341	0	48.20	—	8	56	22.16
15	340	58	13.43	—	8	55	18.66	8	341	0	3.93	—	8	56	42.09
16	340	59	3.15	—	8	55	1.04	9	340	59	18.12	—	8	57	2.63
17	340	59	51.13	—	8	54	44.12	10	340	58	30.76	—	8	57	23.78
18	341	0	37.37	—	8	54	27.91	11	340	57	41.88	—	8	57	45.50
19	341	1	21.86	—	8	54	12.41	12	340	56	51.49	—	8	58	7.81
20	341	2	4.59	—	8	53	57.62	13	340	55	59.61	—	8	58	30.70
21	341	2	45.54	—	8	53	43.54	14	340	55	6.26	—	8	58	54.16
22	341	3	24.71	—	8	53	30.18	15	340	54	11.46	—	8	59	18.17
23	341	4	2.09	—	8	53	17.55	16	340	53	15.22	—	8	59	42.74
24	341	4	37.68	—	8	53	5.65	17	340	52	17.56	—	9	0	7.84
25	341	5	11.46	—	8	52	54.47	18	340	51	18.51	—	9	0	33.47
26	341	5	43.43	—	8	52	44.04	19	340	50	18.11	—	9	0	59.63
27	341	6	13.58	—	8	52	34.33	20	340	49	16.36	—	9	1	26.31
28	341	6	41.90	—	8	52	25.35	21	340	48	13.29	—	9	1	53.49
29	341	7	8.39	—	8	52	17.13	22	340	47	8.92	—	9	2	21.17
30	341	7	33.04	—	8	52	9.64	23	340	46	3.30	—	9	2	49.35
31	341	7	55.85	—	8	52	2.89	24	340	44	56.44	—	9	3	18.00
June 1	341	8	16.83	—	8	51	56.89	25	340	43	48.37	—	9	3	47.12
2	341	8	35.96	—	8	51	51.64	26	340	42	39.10	—	9	4	16.70
3	341	8	53.24	—	8	51	47.12	27	340	41	28.65	—	9	4	46.73
4	341	9	8.69	—	8	51	43.35	28	340	40	17.04	—	9	5	17.18
5	341	9	22.29	—	8	51	40.31	29	340	39	4.31	—	9	5	48.06
6	341	9	34.04	—	8	51	38.02	30	340	37	50.47	—	9	6	19.34
7	341	9	43.95	—	8	51	36.46	31	340	36	35.55	—	9	6	51.01
8	341	9	52.02	—	8	51	35.64	Aug. 1	340	35	19.56	—	9	7	23.05
9	341	9	58.26	—	8	51	35.56	2	340	34	2.55	—	9	7	55.46
10	341	10	2.67	—	8	51	36.22	3	340	32	44.55	—	9	8	28.23
11	341	10	5.25	—	8	51	37.61	4	340	31	25.59	—	9	9	1.35

Ephemeris of Neptune—Continued.

MEAN NOON, WASHINGTON.

Date.	Neptune's Right Ascension.			Neptune's Declination.			Date.	Neptune's Right Ascension.			Neptune's Declination.		
1851.	°	′	″	°	′	″	1851.	°	′	″	°	′	″
Aug. 5	340	30	5.69	— 9	9	34.81	Sept. 28	339	10	24.48	— 9	41	48.74
6	340	28	44.88	— 9	10	8.58	29	339	9	5.19	— 9	42	19.79
7	340	27	23.20	— 9	10	42.68	30	339	7	46.88	— 9	42	50.41
8	340	26	0.69	— 9	11	17.09	Oct. 1	339	6	29.60	— 9	43	20.59
9	340	24	37.40	— 9	11	51.80	2	339	5	13.37	— 9	43	50.32
10	340	23	13.35	— 9	12	26.78	3	339	3	58.22	— 9	44	19.59
11	340	21	48.55	— 9	13	2.01	4	339	2	44.21	— 9	44	48.39
12	340	20	23.03	— 9	13	37.50	5	339	1	31.36	— 9	45	16.70
13	340	18	56.82	— 9	14	13.23	6	339	0	19.68	— 9	45	44.52
14	340	17	29.96	— 9	14	49.18	7	338	59	9.18	— 9	46	11.83
15	340	16	2.49	— 9	15	25.34	8	338	57	59.90	— 9	46	38.62
16	340	14	34.43	— 9	16	1.69	9	338	56	51.87	— 9	47	4.89
17	340	13	5.79	— 9	16	38.22	10	338	55	45.11	— 9	47	30.63
18	340	11	36.61	— 9	17	14.91	11	338	54	39.63	— 9	47	55.83
19	340	10	6.94	— 9	17	51.75	12	338	53	35.43	— 9	48	20.47
20	340	8	36.82	— 9	18	28.73	13	338	52	32.56	— 9	48	44.55
21	340	7	6.26	— 9	19	5.84	14	338	51	31.07	— 9	49	8.06
22	340	5	35.29	— 9	19	43.05	15	338	50	30.97	— 9	49	30.99
23	340	4	3.97	— 9	20	20.36	16	338	49	32.30	— 9	49	53.33
24	340	2	32.34	— 9	20	57.76	17	338	48	35.07	— 9	50	15.07
25	340	1	0.42	— 9	21	35.21	18	338	47	39.32	— 9	50	36.20
26	339	59	28.25	— 9	22	12.71	19	338	46	45.07	— 9	50	56.71
27	339	57	55.87	— 9	22	50.26	20	338	45	52.37	— 9	51	16.60
28	339	56	23.32	— 9	23	27.83	21	338	45	1.23	— 9	51	35.86
29	339	54	50.62	— 9	24	5.41	22	338	44	11.66	— 9	51	54.47
30	339	53	17.82	— 9	24	42.99	23	338	43	23.70	— 9	52	12.43
31	339	51	44.96	— 9	25	20.56	24	338	42	37.38	— 9	52	29.72
Sept. 1	339	50	12.09	— 9	25	58.10	25	338	41	52.71	— 9	52	46.35
2	339	48	39.24	— 9	26	35.58	26	338	41	9.70	— 9	53	2.30
3	339	47	6.44	— 9	27	13.01	27	338	40	28.38	— 9	53	17.57
4	339	45	33.73	— 9	27	50.36	28	338	39	48.79	— 9	53	32.14
5	339	44	1.13	— 9	28	27.62	29	338	39	10.93	— 9	53	46.01
6	339	42	28.69	— 9	29	4.78	30	338	38	34.80	— 9	53	59.18
7	339	40	56.44	— 9	29	41.82	31	338	38	0.42	— 9	54	11.65
8	339	39	24.42	— 9	30	18.74	Nov. 1	338	37	27.82	— 9	54	23.40
9	339	37	52.66	— 9	30	55.50	2	338	36	57.01	— 9	54	34.44
10	339	36	21.19	— 9	31	32.08	3	338	36	27.99	— 9	54	44.75
11	339	34	50.05	— 9	32	8.49	4	338	36	0.78	— 9	54	54.34
12	339	33	19.27	— 9	32	44.71	5	338	35	35.40	— 9	55	3.21
13	339	31	48.89	— 9	33	20.74	6	338	35	11.85	— 9	55	11.35
14	339	30	18.94	— 9	33	56.56	7	338	34	50.13	— 9	55	18.75
15	339	28	49.46	— 9	34	32.15	8	338	34	30.26	— 9	55	25.41
16	339	27	20.48	— 9	35	7.51	9	338	34	12.26	— 9	55	31.31
17	339	25	52.04	— 9	35	42.62	10	338	33	56.14	— 9	55	36.47
18	339	24	24.17	— 9	36	17.48	11	338	33	41.89	— 9	55	40.89
19	339	22	56.91	— 9	36	52.09	12	338	33	29.54	— 9	55	44.56
20	339	21	30.29	— 9	37	26.41	13	338	33	19.07	— 9	55	47.47
21	339	20	4.33	— 9	38	0.42	14	338	33	10.51	— 9	55	49.62
22	339	18	39.09	— 9	38	34.11	15	338	33	3.87	— 9	55	51.01
23	339	17	14.59	— 9	39	7.47	16	338	32	59.15	— 9	55	51.64
24	339	15	50.87	— 9	39	40.48	17	338	32	56.37	— 9	55	51.50
25	339	14	27.97	— 9	40	13.13	18	338	32	55.53	— 9	55	50.59
26	339	13	5.91	— 9	40	45.40	19	338	32	56.63	— 9	55	48.91
27	339	11	44.73	— 9	41	17.27	20	338	32	59.68	— 9	55	46.46

Ephemeris of Neptune—Continued.

MEAN NOON, WASHINGTON.

Date.	Neptune's Right Ascension.			Neptune's Declination.			Date.	Neptune's Right Ascension.			Neptune's Declination.		
1851.	°	′	″	°	′	″	1851.	°	′	″	°	′	″
Nov. 21	338	33	4.70	— 9	55	43.22	Dec. 13	338	43	8.38	— 9	51	18.63
22	338	33	11.68	— 9	55	39.22	14	338	43	57.75	— 9	50	58.04
23	338	33	20.62	— 9	55	34.45	15	338	44	48.96	— 9	50	36.73
24	338	33	31.52	— 9	55	28.90	16	338	45	41.99	— 9	50	14.70
25	338	33	44.40	— 9	55	22.57	17	338	46	36.84	— 9	49	51.97
26	338	33	59.24	— 9	55	15.47	18	338	47	33.50	— 9	49	28.53
27	338	34	16.05	— 9	55	7.60	19	338	48	31.96	— 9	49	4.39
28	338	34	34.81	— 9	54	58.96	20	338	49	32.21	— 9	48	39.55
29	338	34	55.53	— 9	54	49.55	21	338	50	34.22	— 9	48	14.03
30	238	35	18.21	— 9	54	39.38	22	338	51	37.98	— 9	47	47.83
Dec. 1	338	35	42.85	— 9	54	28.44	23	338	52	43.49	— 9	47	20.94
2	338	36	9.45	— 9	54	16.74	24	338	53	50.72	— 9	46	53.37
3	338	36	37.98	— 9	54	4.28	25	338	54	59.65	— 9	46	25.15
4	238	37	8.44	— 9	53	51.06	26	338	56	10.27	— 9	45	56.27
5	338	37	40.83	— 9	53	37.09	27	338	57	22.56	— 9	45	26.74
6	338	38	15.15	— 9	53	22.37	28	338	58	36.51	— 9	44	56.57
7	338	38	51.37	— 9	53	6.91	29	338	59	52.09	— 9	44	25.76
8	338	39	29.49	— 9	52	50.70	30	339	1	9.28	— 9	43	54.34
9	338	40	9.51	— 9	52	33.76	31	339	2	28.04	— 9	43	22.31
10	338	40	51.42	— 9	52	16.07	32	339	3	48.39	— 9	42	49.68
11	338	41	35.21	— 9	51	57.65	33	339	5	10.29	— 9	42	16.45
12	338	42	20.87	— 9	51	38.50							

Date 1851.	Heliocentric co-ordinates of Neptune for mean noon, Washington, referred to the apparent equinox and equator.			Logarithm of Neptune's distance from the Earth.
	x	y	z	Log. Δ
January 4	27.45465	— 10.83466	— 5.151569	1.4852453
12	27.46460	— 10.81299	— 5.142940	1.4866945
20	27.47452	— 10.79133	— 5.134314	1.4879450
28	27.48442	— 10.76967	— 5.125690	1.4889786
February 5	27.49430	— 10.74801	— 5.117067	1.4897749
13	27.50416	— 10.72636	— 5.108444	1.4903235
21	27.51399	— 10.70471	— 5.099822	1.4906177
1	27.52380	— 10.68307	— 5.091199	1.4906541
March 9	27.53358	— 10.66143	— 5.082576	1.4904323
17	27.54334	— 10.63979	— 5.073943	1.4899564
25	27.55309	— 10.61815	— 5.065308	1.4892389
April 2	27.56282	— 10.59651	— 5.056669	1.4882904
10	27.57252	— 10.57487	— 5.048023	1.4871255
18	27.58221	— 10.55322	— 5.039369	1.4857679
26	27.59189	— 10.53154	— 5.030703	1.4842382
May 4	27.60156	— 10.50983	— 5.022029	1.4825614
12	27.61122	— 10.48808	— 5.013347	1.4807661
20	27.62086	— 10.46631	— 5.004654	1.4788849
28	27.63049	— 10.44453	— 4.995952	1.4769480
June 5	27.64010	— 10.42274	— 4.987245	1.4749899
13	27.64969	— 10.40093	— 4.978538	1.4730477
21	27.65926	— 10.37910	— 4.969832	1.4711539
29	27.66881	— 10.35727	— 4.961124	1.4693444
July 7	27.67833	— 10.33544	— 4.952414	1.4676567
15	27.68784	— 10.31360	— 4.943702	1.4661207
23	27.69733	— 10.29172	— 4.934989	1.4647687
31	27.70680	— 10.26982	— 4.926278	1.4636278
August 8	27.71625	— 10.24790	— 4.917568	1.4627247
16	27.72567	— 10.22603	— 4.908861	1.4620792
24	27.73507	— 10.20419	— 4.900155	1.4617038
September 1	27.74443	— 10.18239	— 4.891441	1.4616118
9	27.75377	— 10.16059	— 4.882726	1.4618024
17	27.76310	— 10.13879	— 4.874010	1.4622758
25	27.77241	— 10.11696	— 4.865293	1.4630228
October 3	27.78169	— 10.09512	— 4.856576	1.4640292
11	27.79096	— 10.07327	— 4.847850	1.4652729
19	27.80021	— 10.05141	— 4.839111	1.4667290
27	27.80945	— 10.02954	— 4.830364	1.4683682
November 4	27.81868	— 10.00764	— 4.821606	1.4701559
12	27.82789	— 9.98571	— 4.812841	1.4720542
20	27.83708	— 9.96377	— 4.804067	1.4740269
28	27.84626	— 9.94182	— 4.795283	1.4760340
December 6	27.85542	— 9.91985	— 4.786500	1.4780348
14	27.86456	— 9.89784	— 4.777716	1.4799910
22	27.87369	— 9.87584	— 4.768927	1.4718672
30	27.88280	— 9.85385	— 4.760134	1.4736268
38	27.89188	— 9.83185	— 4.751336	1.4752396

OCCULTATIONS

VISIBLE IN THE UNITED STATES

DURING THE YEAR

1851.

COMPUTED BY JOHN DOWNES,

AT THE

EXPENSE OF THE FUND APPROPRIATED BY CONGRESS

FOR THE ESTABLISHMENT OF A

Nautical Almanac,

AND PUBLISHED BY THE SMITHSONIAN INSTITUTION.

WASHINGTON.

1850.

Smithsonian Institution.

PREFACE.

For the purpose of facilitating the accurate determination of the geographical position of important points in the United States, the Regents of the Smithsonian Institution authorized the preparation of lists of occultations and co-ordinates of reduction to particular places for the years 1848 and 1849. Congress has, since, ordered the publication of an American Nautical Almanac; and, as lists of Occultations will form a regular part of this ephemeris, Mr. Preston, the late Secretary of the Navy, directed that the expense of computing these tables for 1850 should be defrayed from the appropriation for the almanac—the printing and distribution to be done by the Smithsonian Institution. A similar order has been given by Mr. Graham, the present Secretary of the Navy, relative to the tables for 1851.

Copies of these elements will be forwarded to all persons disposed to advance the science of geography, with the request, that the results of the observations which may be made, be sent to the Smithsonian Institution, or published in some accessible scientific journal.

The following remarks by the computer will give a more definite idea of the nature and object of this publication.

JOSEPH HENRY, *Secretary S. I.*
CHARLES H. DAVIS, *Superintendent of the Nautical Almanac.*

In preparing the following lists, I have endeavoured to afford to conductors of the exploring operations which will, doubtless, be prosecuted by our government in the newly acquired and other extensive territories of the West, every facility for the determination of the longitude of important points. With this view, I have included in the first or general list all the

occultations that can be made available for this purpose on any part of the American continent included between the parallels of 15° and 50° north.

The selection comprises the larger planets and all stars to the fourth magnitude, inclusive, which can be occulted to any part of North America within the above-named limits, whether by day or night. In the observation of an occultation taking place while the sun is above the horizon, the observer must of course be guided in his search for the star by the moon itself. If the points on the moon's border where the immersion and emersion are to take place have been computed, there can be no difficulty, provided the telescope employed be of sufficient optical power to show the star distinctly when once brought into the field. A very good observation may be made, by daylight, with a three or a three-and-a-half feet telescope, if the occultation be one of the largest class of stars; but, so far as my own experience goes, I do not think that a good observation can be obtained under these circumstances, where the occultation is of a star less than that of the second or third magnitude. An approximate knowledge of the longitude, however, is always desirable where a more perfect one cannot be had, and it was therefore thought advisable to extend the daylight occultations to stars of the fourth magnitude.

All the stars of the *British Association Catalogue*, of whatever magnitude, that can be occulted in the absence of sunlight, between the times of *change* and of *full moon*, and between the times of *last quarter* and of *change*, have been selected from that work. For a few days following the *full*, the occultations of stars smaller than of the sixth magnitude have been omitted; the difficulty of ascertaining the precise instant of their emersions being so great at this period of the lunation as to render the observations useless.

The general list has been still farther extended by including such stars of the eighth and ninth magnitudes as can be occulted during the most favourable period of each lunation, the first seven or eight days following the *change*. All those of *Lalande's Catalogue* of nearly fifty thousand stars, and of *Weisse's Catalogue* of nearly thirty thousand stars, which can be occulted under circumstances favourable for observation, are probably included in this list. In the occultation lists published in Europe, stars of this class are not included. I know of no reason why they should be rejected, unless it be that computers shrink from the labour of making the necessary calculations. Though less interesting, perhaps, regarded merely as phenomena,

their occultations are equally valuable for the determination of longitudes with those of the larger stars; and, if we consider their much more frequent occurrence, they give a very great advantage which the others do not possess, and which ought not to be neglected. The observations are not difficult, and do not, as many suppose, require instruments of great power. A three or three-and-a-half feet telescope is sufficient. Nor is it necessary that the daylight be entirely ended. An occultation, which deserves notice on account of the smallness of the star and the early hour at which it took place, was observed at the *Friends' Observatory* in Philadelphia on the 6th of June, 1848. The computed sidereal time of the end of twilight on that evening was $14^h\ 29^m$. The star was No. 3418, *British Association Catalogue*, of the *eighth magnitude*. The immersion took place at $13^h\ 29^m\ 21^s.4$, sidereal time, or one hour before the end of twilight. The observations were made with a seven feet *equatorial* and with a three-and-a-half feet portable telescope, and were perfectly satisfactory with both instruments; the noted time of the star's disappearance being almost identical. The star was readily found on directing the small telescope to the adjacent limb of the moon, at least ten minutes before its immersion, and was steadily and distinctly visible up to the instant of occultation. From the perfect ease with which it could be seen, there is no doubt that good observations could have been obtained, had the star been of the ninth or even of the tenth magnitude.

The Washington mean solar time, T, the Washington hour-angle of the star, H, the log. sine and cosine of the star's declination, the co-ordinates p, q, and their hourly variations, p', q', are given for the purpose of facilitating the computation of the occultations for any given place. This arrangement leaves no further labour to be performed by the computer than what depends on the longitude and latitude of his position. This labour is by no means so serious as might be apprehended from a first glance at the example worked out on pages 22 and 23. Every part of the process is there given, and the work certainly appears of some length; but, with suitable logarithmic tables, the calculations are very rapidly made, and an expert computer will find it easy to determine all the circumstances necessary to an observation in a few minutes.

By the last column of the general list, will be seen on what part of the continent an occultation, not visible at Washington, may be expected to take place under favourable circumstances for observation. Where

no particular region is mentioned, the occultation will be visible at Washington.

In order to render this list available, as far as possible, to all who take an interest in phenomena of this nature, I have given so much of Professor Bessel's method of predicting occultations as may be necessary for determining, from the quantities T, H, etc., all the particulars required for the purpose of making an observation, with an example of its practical application.

The second list has been prepared with particular reference to the *National Observatory* at Washington. The mean solar and sidereal times of the immersions and emersions, with the angular positions on the moon's border of the points of contact of all stars to the seventh magnitude inclusive, which will be favourably occulted, have been computed as they will be seen at that place. In the few instances where occultations which take place below the horizon are given, the times of immersion and emersion may serve the purposes of observation at places not far distant from Washington.

JOHN DOWNES.

PHILADELPHIA, *October*, 1850.

For facilitating the Computation of such Occultations of Planets and Stars by the Moon *as will be visible in North America during the year* 1851.

1851.	Star's Name.	Mag.	*T*	*H*	Log sin *D*	Log cos *D*	*p*	*q*	*p'*	*q'*	Where visible.
			h. m.	° ′							
Jan. 4	Lal. 40386	8½	1 51.8	− 0 05.7	−9.5159	9.9753	+0.3624	+1.0283	.5381	+.0978	Newfoundland.
5	Lal. 42684	8	7 51.8	+ 76 14.1	−9.4392	.9830	+0.5818	1.0474	.5272	+.1383	
5	B.A.C.7640	7½	9 51.8	+105 37.1	−9.4358	.9832	+0.8886	1.1830	.5263	+.1401	Oregon.
6	543 Hora 22	9	3 21.8	− 0 13.1	−9.3570	.9885	+0.3212	0.8271	.5217	+.1582	Newfoundland.
6	604 Hora 22	9	5 11.8	+ 26 36.9	−9.3570	.9885	+0.4739	1.1166	.5205	+.1602	N. E. States.
6	607 Hora 22	9	5 11.8	+ 26 35.8	−9.3515	.9888	+0.4544	0.9281	.5208	+.1602	
6	617 Hora 22	8	5 11.8	+ 26 32.0	−9.3353	.9896	+0.3872	0.3917	.5218	+.1602	Southern States.
6	691 Hora 22	8½	7 36.8	+ 62 04.0	−9.3312	.9898	+0.7593	0.6473	.5210	+.1632	
6	767 Hora 22	9	9 21.8	+ 87 30.7	−9.3273	.9900	+0.7216	0.8044	.5200	+.1637	Oregon & California.
6	814 Hora 22	9	10 51.8	+109 30.0	−9.3292	.9899	+0.8774	1.1128	.5190	+.1650	Oregon.
6	816 Hora 22	8	10 51.8	+109 28.2	−9.3161	.9905	+0.8461	0.6976	.5198	+.1650	California & Mexico.
6	881 Hora 22	8	12 36.8	+134 59.4	−9.3226	.9902	+0.8833	1.1970	.5186	+.1662	Oregon.
7	260 Hora 23	8	4 03.8	− 0 27.5	−9.2280	.9937	+0.3465	1.1970	.5156	+.1782	Newfoundland.
7	272 Hora 23	8	4 33.8	+ 6 55.6	−9.2172	.9940	+0.4563	1.0144	.5157	+.1782	Newfoundland.
7	45745 Lal.	8	4 33.8	+ 6 45.9	−9.2210	.9939	+0.2803	1.1087	.5157	+.1782	Lower Canada.
7	322 Hora 23	8	5 39.8	+ 22 49.8	−9.2074	.9943	+0.3228	0.9739	.5158	+.1788	
7	B.A.C. 8154	7	5 39.8	+ 22 49.7	−9.2074	.9943	+0.3214	0.9745	.5158	+.1788	
7	336 Hora 23	9	6 21.8	+ 33 11.2	−9.1945	.9946	+0.4966	0.7971	.5157	+.1794	
7	364 Hora 23	9	7 21.8	+ 47 54.3	−9.1771	.9951	+0.6586	0.5824	.5159	+.1800	
7	573 Hora 23	8	13 03.8	+131 10.6	−9.1588	.9954	+0.9016	1.2212	.5144	+.1836	Oregon.
8	16 Hora 0	9	6 06.8	+ 19 03.8	−8.8956	.9987	+0.2925	0.2492	.5150	+.1913	Southern States.
8	86 Hora 0	8	8 21.8	+ 52 06.5	−8.8658	.9988	+0.5769	0.3503	.5147	+.1920	Southern States.
8	103 Hora 0	7½	9 06.8	+ 63 06.9	−8.9168	.9985	+0.6613	1.0725	.5144	+.1923	N. W. Territories.
8	127 Hora 0	9	9 21.8	+ 81 33.3	−8.8929	.9987	+0.9091	1.0335	.5145	+.1927	Northern States.
8	204 Hora 0	8	12 39.8	+115 03.0	−8.7612	.9993	+0.8888	0.1871	.5150	+.1932	California & Mexico.
8	235 Hora 0	7½	13 21.8	+125 14.2	−8.8586	9.9989	+0.8738	1.2368	.5145	+.1935	Oregon.
9	832 Hora 0	8	6 11.8	+ 9 50.8	−8.1372	0.0000	+0.1784	0.8482	.5177	+.1966	
9	858 Hora 0	8	7 21.8	+ 27 02.2	−7.7918	0.0000	+0.3922	0.6074	.5178	+.1966	
9	861 Hora 0	8	7 21.8	+ 26 58.9	−7.9080	0.0000	+0.3323	0.7258	.5178	+.1966	
9	904 Hora 0	8	9 21.8	+ 56 31.1	−6.5664	0.0000	+0.7739	0.6371	.5183	+.1967	
11	ξ^2 Ceti	4	3 51.8	− 46 21.3	+9.1319	9.9960	−0.5968	0.4496	.5365	+.1864	
11	B. A. C. 845	4	14 33.8	+110 25.4	+9.2167	.9940	+0.8194	0.6114	.5435	+.1796	
12	*f* Tauri	5½	11 21.8	+ 51 50.1	+9.3327	.9897	+0.5031	1.0605	.5601	+.1602	Oregon.
13	48 Tauri	6	5 21.8	− 48 35.5	+9.4136	.9849	−0.4973	1.0418	.5753	+.1367	Newfoundland.
13	γ Tauri	3½	6 51.8	− 27 01.8	+9.4203	.9844	−0.6250	0.9965	.5763	+.1344	N. W. Territories.
13	55 Tauri	7	6 51.8	− 27 02.9	+9.4445	.9825	−0.6399	0.0763	.5738	+.1344	Texas.
13	63 Tauri	6	9 51.8	+ 17 12.2	+9.4514	.9819	+0.2295	0.1992	.5766	+.1298	
13	B.A.C. 1351	6½	9 51.8	+ 17 11.3	+9.4476	.9822	+0.2141	0.3511	.5770	+.1298	
13	70 Tauri	7	9 33.8	+ 12 07.8	+9.4294	.9837	−0.4982	1.0111	.5784	+.1305	Oregon.
13	75 Tauri	6	12 51.8	+ 61 03.8	+9.4409	.9828	+0.7248	0.9931	.5814	+.1249	Canada.
13	α Tauri	1	15 51.8	+104 19.5	+9.4457	.9824	+0.6442	1.1711	.5849	+.1199	Oregon.
14	B.A.C. 1625	7	7 21.8	− 32 42.1	+9.4962	.9775	−0.0663	0.7036	.5955	+.0909	
14	119 Tauri	5½	13 51.8	+ 61 12.2	+9.5010	.9770	+0.1317	1.0366	.6017	+.0774	Oregon.
15	68 Orionis	6	4 01.8	− 95 38.8	+9.5302	.9735	−0.6891	0.5635	.6094	+.0446	Newfoundland.
15	16 Geminor	6	11 33.8	+ 13 41.5	+9.5459	.9714	+0.1954	0.0760	.6109	+.0277	
15	ν Geminor	4	12 06.8	+ 21 42.4	+9.5402	.9721	+0.2915	0.3681	.6125	+.0253	
15	B.A.C.2173	7	16 51.8	+ 90 22.3	+9.5296	.9736	+0.6176	0.9718	.6166	+.0141	N. W. Territories.
16	61 Geminor	7	8 51.8	− 40 42.0	+9.5453	.9714	−0.3955	0.1152	.6170	−.0263	
16	B.A.C.2499	7	13 01.8	+ 19 25.7	+9.5441	.9716	−0.1715	0.0449	.6172	−.0378	S. W. Territories.
16	B.A.C.2605	7	20 01.8	+120 58.8	+9.5278	.9738	+0.7027	0.4981	.6187	−.0554	Oregon.
17	d^1 Cancri	6	5 36.8	−102 46.1	+9.5083	.9762	−0.6863	0.7403	.6183	−.0775	Nova Scotia.
17	θ Cancri	5½	8 51.8	− 55 57.1	+9.5036	.9767	−0.6005	+0.6831	.6172	−.0858	
17	δ Cancri	4½	15 15.8	+ 37 02.0	+9.5059	.9765	+0.2875	−0.0165	.6126	−.1009	S. W. Territories.
20	B.A.C 3996	6	18 09.8	+ 37 17.7	+9.0207	.9976	+0.2874	+0.1608	.5698	−.2063	S. W. Territories.
22	80 Virginis	6	18 21.8	+ 15 41.9	−8.9075	.9986	+0.3548	0.8606	.5504	−.2056	N. E. States.

For facilitating the Computation of such Occultations of Planets and Stars by the Moon *as will be visible in North America during the year* 1851.

1851.	Star's Name.	Mag.	T	H	Log sin D	Log cos D	p	q	p'	q'	Where visible.
			h. m.	° ′							
Jan 23	B.A.C. 4794	7	18 39.8	+ 7 59.7	−9.2100	9.9942	+0.1057	+0.9196	.5464	−.1897	
26	29 Ophiuchi	6	16 51.8	− 54 15.3	−9.5051	.9765	−0.6521	0.4071	.5513	−.0984	Southern States.
28	μ^1 Sagittarii	4	1 51.8	+ 64 10.4	−9.5561	.9699	−0.7501	0.7547	.5523	−.0402	California & Mexico.
28	33 Sagittarii	6	20 21.8	− 27 37.6	−9.5648	.9686	−0.8164	0.8181	.5516	−.0060	Oregon & California.
29	ξ^2 Sagittarii	4	0 15.8	+ 30 05.9	−9.5601	.9693	+0.3778	0.5460	.5522	+.0014	Southern States.
Feb. 2	45 Aquarii	6	2 45.8	+ 21 05.4	−9.3851	.9868	+0.6362	0.7142	.5256	+.1519	Newfoundland.
2	341 Hora 22	9	5 51.8	+ 66 20.8	−9.3820	.9870	+0.7825	1.0772	.5241	+.1549	
2	343 Hora 22	8	5 51.8	+ 66 19.5	−9.3817	.9870	+0.7587	1.0651	.5241	+.1549	
2	352 Hora 22	9	5 51.8	+ 66 17.1	−9.3826	.9870	+0.7166	1.0980	.5241	+.1549	N. E. States.
2	363 Hora 22	9	6 21.8	+ 73 42.0	−9.3762	.9874	+0.8650	0.9421	.5243	+.1554	
2	388 Hora 22	9	6 51.8	+ 80 57.7	−9.3699	.9877	+0.8478	0.7971	.5244	+.1559	Western Territories.
2	415 Hora 22	8	7 36.8	+ 91 54.7	−9.3530	.9887	+0.8851	0.3279	.5252	+.1564	California & Mexico.
2	420 Hora 22	9	7 36.8	+ 91 51.2	−9.3534	.9886	+0.8211	0.3410	.5250	+.1564	California & Mexico.
2	B.A.C. 7835	6½	8 45.8	+108 34.6	−9.3737	.9875	+0.8002	1.2280	.5231	+.1573	Oregon.
3	1241 Hora 22	7	3 21.8	+ 19 13.9	−9.2561	.9928	+0.5907	0.6602	.5192	+.1735	Newfoundland.
3	7 Hora 23	9	5 21.8	+ 48 32.9	−9.2394	.9933	+0.7934	0.5682	.5189	+.1750	Nova Scotia.
3	42 Hora 23	9	6 15.8	+ 61 37.2	−9.2403	.9933	+0.7498	0.7494	.5184	+.1757	
3	56 Hora 23	9	6 51.8	+ 85 27.4	−9.2322	.9936	+0.8566	0.6467	.5184	+.1761	
3	84 Hora 23	8	7 21.8	+ 77 35.4	−9.2274	.9937	+0.6912	0.6145	.5184	+.1764	
3	93 Hora 23	9	7 45.8	+ 83 32.6	−9.2223	.9939	+0.8308	0.5580	.5184	+.1767	Southern States.
3	103 Hora 23	8	7 51.8	+ 84 58.3	−9.2280	.9937	+0.7987	0.7181	.5182	+.1767	Western States.
3	109 Hora 23	9	7 51.8	+ 84 55.6	−9.2287	.9937	+0.7489	0.7354	.5182	+.1767	Western States.
3	144 Hora 23	9	8 51.8	+ 99 34.9	−9.2350	.9935	+0.8427	1.1718	.5175	+.1774	N. W. Territories.
3	ψ^1 Aquarii	5½	8 51.8	+ 99 34.0	−9.2354	.9935	+0.8285	1.0450	.5175	+.1774	N. W. Territories.
3	ψ^3 Aquarii	5	9 51.8	+114 05.3	−9.2396	.9934	+0.7766	1.3671	.5168	+.1780	Oregon.
4	895 Hora 23	8	3 21.8	+ 8 48.9	−9.0543	.9972	+0.5152	0.6977	.5151	+.1878	Newfoundland.
4	1016 Hora 23	8	6 41.8	+ 57 36.0	−9.0393	.9974	+0.7181	1.0789	.5147	+.1892	Northern States.
4	1029 Hora 23	8	7 06.8	+ 63 42.4	−9.0396	.9974	+0.7567	1.1625	.5147	+.1892	Northern States.
4	1154 Hora 23	8	10 03.8	+106 41.1	−8.9410	.9983	+0.7413	0.3050	.5150	+.1905	California & Mexico.
4	1161 Hora 23	8	10 36.8	+114 47.9	−8.9522	.9983	+0.8496	0.5549	.5149	+.1906	California & Mexico.
5	712 Hora 0	8	10 21.8	+100 56.0	−8.3563	.9999	+0.8628	0.9224	.5155	+.1959	N. W. Territories.
5	732 Hora 0	7	11 11.8	+113 04.5	−8.2573	.9999	+0.8612	0.7934	.5156	+.1960	N. W. Territories.
6	295 Hora 1	7	5 11.8	+ 14 53.3	+8.5834	.9997	+0.3869	0.7732	.5190	+.1952	N. E. States.
6	322 Hora 1	7	6 15.8	+ 30 37.8	+8.6830	.9995	+0.6097	0.3629	.5188	+.1948	Southern States.
6	420 Hora 1	8	9 33.8	+ 78 55.7	+8.7066	.9994	+0.8670	0.8360	.5200	+.1944	
6	427 Hora 1	8	9 45.8	+ 81 52.4	+8.7836	.9992	+0.9014	0.2579	.5198	+.1944	Southern States.
6	454 Hora 1	8	10 33.8	+ 93 31.1	+8.7684	.9992	+0.8976	0.5441	.5201	+.1941	
6	493 Hora 1	8	11 41.8	+110 00.8	+8.7921	.9992	+0.8851	0.5578	.5205	+.1938	Western Territories.
7	158 Hora 2	7	9 09.8	+ 62 19.9	+9.1152	.9963	+0.7377	0.3680	.5289	+.1854	
7	160 Hora 2	8	9 09.8	+ 62 18.8	+9.0870	.9967	+0.7199	0.8776	.5294	+.1854	
7	235 Hora 2	8	11 31.8	+ 96 52.3	+9.1362	.9959	+0.8612	0.4027	.5294	+.1842	S. W. Territories.
7	ξ^2 Ceti	4	14 06.8	+134 25.9	+9.1319	.9960	+0.8494	0.9587	.5322	+.1826	Oregon.
9	α Tauri	1	22 51.8	−123 46.4	+9.4457	.9824	−0.7226	0.9139	.5707	+.1216	Newfoundland.
10	m Tauri	5½	14 51.8	+109 03.9	+9.5001	.9771	+0.7936	0.3283	.5813	+.0939	Oregon & California
11	χ^2 Orionis	6	9 15.8	+ 13 57.0	+9.5280	.9738	+0.1740	0.4157	.5951	+.0562	
11	χ^3 Orionis	5	13 36.8	+ 77 15.0	+9.5274	.9738	+0.7408	0.6676	.5981	+.0474	
11	χ^4 Orionis	5	13 51.8	+ 80 54.1	+9.5368	.9726	+0.7850	0.2257	.5970	+.0463	Southern States.
11	68 Orionis	6	17 01.8	+126 30.0	+9.5302	.9735	+0.7539	0.6803	.6012	+.0383	Oregon & California.
12	ζ Geminor	4	12 51.8	+ 51 47.8	+9.5500	.9708	+0.5045	0.0194	.6077	−.0083	S. W. Territories.
13	B.A.C. 2605	7	5 51.8	− 64 30.3	+9.5278	.9738	−0.2680	0.5901	.6140	−.0504	Newfoundland.
13	B.A.C. 2683	6	10 51.8	+ 7 29.0	+9.5183	.9750	−0.1874	0.7411	.6152	−.0628	Northern States.
13	d^1 Cancri	6	19 21.8	+130 39.6	+9.5084	.9762	+0.6926	0.5625	.6145	−.0834	Oregon.
14	B.A.C. 3029	7	5 15.8	− 88 28.3	+9.4851	.9787	−0.7165	0.6145	.6132	−.1065	N. E. States.
14	B.A.C. 3044	7	5 51.8	− 79 53.4	+9.4832	.9789	−0.7626	0.6299	.6131	−.1077	
14	68 Cancri	7	7 51.8	− 50 57.6	+9.4820	9.9790	−0.6112	+0.4605	.6122	−.1121	

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1851.	Star's Name.	Mag.	T (h. m.)	H (° ′)	Log sin D	Log cos D	p	q	p′	q′	Where visible.
Feb 17	b Virginis	5½	7 09.8	−103 16.3	+8.8930	9.9987	−0.7889	+1.0634	.5798	−.2121	Newfoundland.
20	ξ^1 Libræ	6	12 51.8	− 58 04.4	−9.2917	.9915	−0.5744	0.8880	.5546	−.1824	
20	ξ^3 Libræ	5	13 51.8	− 43 37.8	−9.2729	.9922	−0.6285	0.2072	.5558	−.1813	Mexico.
21	η Libræ	4½	11 06.8	− 95 45.6	−9.4184	.9845	−0.7919	1.2117	.5519	−.1543	Newfoundland.
21	49 Libræ	5½	19 33.8	+ 27 16.0	−9.4428	.9826	−0.2547	0.9116	.5525	−.1429	Oregon.
24	B.A.C. 6336	6½	18 51.8	− 19 34.0	−9.5644	.9686	−0.7464	0.8274	.5504	−.0192	Oregon.
25	B.A.C. 6641	7	17 45.8	− 47 16.5	−9.5647	.9686	−0.6086	0.8993	.5470	+.0232	
Mar. 4	398 Hora 0	7½	7 27.8	+ 88 05.3	−8.6594	.9995	+0.8865	0.7342	.5169	+.1966	
5	125 Hora 1	8	7 11.8	+ 73 51.0	+8.5314	.9997	+0.8451	0.3993	.5195	+.1972	
5	156 Hora 1	8	8 06.8	+ 87 13.1	+8.4890	.9998	+0.8622	0.7786	.5199	+.1971	
5	197 Hora 1	9	9 21.8	+105 30.1	+8.4730	.9998	+0.9445	1.0919	.5200	+.1969	N. W. States.
6	B. A. C. 612	7	5 27.8	+ 37 57.0	+8.9664	.9981	+0.6765	1.0556	.5255	+.1910	N. E. States.
6	1031 Hora 1	7	8 51.8	+ 87 38.5	+9.0413	.9973	+0.8949	0.6097	.5263	+.1894	
6	1033 Hora 1	8	8 51.8	+ 87 36.5	+9.0166	.9976	+0.8588	0.9906	.5266	+.1894	Northern States.
6	1095 Hora 1	9	10 21.8	+109 25.5	+9.0590	.9971	+0.8437	0.6063	.5267	+.1887	Western Territories.
7	B. A. C. 845	4	2 21.8	− 18 51.9	+9.2167	.9940	−0.2762	0.4050	.5330	+.1787	
8	569 Hora 3	8	5 45.8	+ 19 43.6	+9.3652	.9880	+0.2962	0.7530	.5480	+.1527	
8	677 Hora 3	9	8 51.8	+ 80 11.2	+9.3881	.9866	+0.7863	0.4286	.5489	+.1491	
8	688 Hora 3	9	9 11.8	+ 70 02.1	+9.3768	.9873	+0.7912	0.8766	.5504	+.1486	Northern States.
8	727 Hora 3	9	9 36.8	+ 75 52.3	+9.3860	.9867	+0.5848	0.6164	.5495	+.1485	
8	737 Hora 3	9	9 51.8	+ 79 32.5	+9.3805	.9871	+0.6285	0.8455	.5505	+.1479	Northern States.
8	777 Hora 3	9	11 21.8	+101 33.2	+9.3991	.9859	+0.8857	0.4071	.5505	+.1460	Western Territories.
8	788 Hora 3	9	11 21.8	+101 26.9	+9.4020	.9857	+0.7771	0.3015	.5504	+.1460	S. W. Territories.
9	Lal. 8610	8	7 27.8	+ 32 26.0	+9.4581	.9813	+0.4210	0.7656	.5640	+.1177	Northern States.
9	Lal. 8613	8	7 27.8	+ 32 25.1	+9.4632	.9808	+0.4056	0.5530	.5634	+.1177	
9	Rumk. 1246	7	11 01.8	+ 84 26.5	+9.4690	.9803	+0.7881	0.7165	.5661	+.1121	
11	16 Geminor	6	6 41.8	− 5 17.7	+9.5459	.9714	+0.0981	0.2239	.5898	+.0268	Nova Scotia.
11	ν Geminor	4	6 51.8	− 3 02.8	+9.5402	.9721	−0.0507	0.5134	.5911	+.0257	
12	61 Geminor	7	6 06.8	− 27 51.3	+9.5453	.9714	+0.0001	0.2289	.5988	−.0288	Nova Scotia.
12	B.A.C. 2499	7	10 51.8	+ 41 02.8	+9.5441	.9716	+0.4476	0.1311	.5992	−.0395	
12	B.A.C. 2605	7	17 21.8	+135 04.7	+9.5278	.9738	+0.8339	0.6126	.6024	−.0548	Oregon.
13	θ Cancri	5½	6 51.8	− 31 49.4	+9.5036	.9767	−0.4103	0.7614	.6038	−.0862	N. E. States.
13	44 Cancri	7½	12 51.8	+ 55 31.8	+9.5056	.9765	+0.4808	0.1141	.6014	−.0997	Southern States.
13	δ Cancri	4½	13 36.8	+ 66 25.5	+9.5059	.9765	+0.5685	0.0232	.6013	−.1008	S. W. Territories.
13	B.A.C. 3015	7	17 21.8	+120 41.0	+9.4882	.9784	+0.8061	0.3918	.6021	−.1096	Oregon & California.
13	B.A.C. 3029	7	18 06.8	+131 25.1	+9.4851	.9787	+0.7425	0.4410	.6021	−.1117	Oregon & California.
13	B.A.C. 3044	7	18 51.8	+142 15.3	+9.4832	.9789	+0.7757	0.4374	.6021	−.1128	Oregon & California.
15	B.A.C. 3662	7½	11 31.8	+ 7 39.4	+9.3002	.9912	+0.1066	0.3627	.5921	−.1849	
16	B.A.C. 3940	7	9 09.8	− 40 43.8	+9.0818	.9968	−0.5015	0.5794	.5845	−.2084	
16	B.A.C. 3947	7	9 33.8	− 34 53.4	+9.0916	.9967	−0.4402	0.3407	.5845	−.2084	
16	B.A.C. 3996	6	15 51.8	+ 56 54.4	+9.0206	.9976	+0.3432	0.0660	.5818	−.2130	California & Mexico.
18	80 Virginis	6	12 21.8	− 20 20.3	−8.9076	.9986	−0.3018	0.9070	.5695	−.2152	
20	γ Libræ	4½	18 15.8	+ 40 31.1	−9.3924	.9863	+0.3650	0.3493	.5640	−.1607	Mexico.
21	χ Ophiuchi	5	16 21.8	+ 0 22.7	−9.4926	.9779	−0.0059	1.1671	.5601	−.1257	Northern States.
23	μ^1 Sagittarii	4	14 51.8	− 47 04.4	−9.5561	.9699	−0.6605	0.4714	.5574	−.0396	Southern States.
23	14 Sagittarii	6	15 21.8	− 39 40.1	−9.5688	.9679	−0.4962	1.1596	.5547	−.0387	Canada.
24	o Sagittarii	4½	13 51.8	− 73 51.1	−9.5727	.9673	−0.7689	1.0097	.5504	+.0043	Eastern States.
24	B.A.C. 6561	6	18 15.8	− 24 37.9	−9.5717	.9675	−0.3348	0.9897	.5497	+.0127	Oregon.
27	γ^1 Capricorni	4	16 39.8	− 67 47.9	−9.4741	.9798	−0.7822	1.1005	.5290	+.1267	
27	δ Capricorni	3½	21 21.8	+ 1 09.0	−9.4610	.9810	−0.1554	1.1212	.5275	+.1331	Canada.
28	50 Aquarii	6	15 15.8	− 99 02.2	−9.3921	.9864	−0.8427	0.8945	.5236	+.1540	Newfoundland.
Apr. 3	498 Hora 2	9	6 21.8	+ 69 45.9	+9.1901	.9947	+0.7520	0.8535	.5266	+.1797	Nova Scotia.
3	B. A. C. 826	7	8 51.8	+106 13.9	+9.2355	.9935	+0.8937	0.2532	.5367	+.1810	S. W. Territories.
3	602 Hora 2	9	9 06.8	+109 50.7	+9.2018	.9944	+0.8732	1.1028	.5379	+.1806	N. W. Territories.
3	B. A. C. 845	4	10 15.8	+126 34.4	+9.2167	9.9940	+0.8861	+0.9636	.5380	+.1798	Oregon.

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1851.	Star's Name.	Mag.	*T*	*H*	Log sin *D*	Log cos *D*	*p*	*q*	*p′*	*q′*	Where visible.
			h. m.	° ′							
Apr. 3	657 Hora 2	9	10 51.8	+135 20.6	+9.2291	9.9937	+0.9378	+0.7716	.5380	+.1794	Oregon & California.
4	306 Hora 3	9	5 51.8	+ 51 13.6	+9.3551	.9885	+0.8128	0.4312	.5466	+.1612	Nova Scotia.
4	447 Hora 3	8	9 33.8	+104 59.1	+9.3611	.9882	+0.8682	0.8228	.5492	+.1572	Mississippi.
4	474 Hora 3	9	10 03.8	+112 11.6	+9.3736	.9875	+0.8160	0.4768	.5492	+.1560	Western Territories.
4	495 Hora 3	9½	10 21.8	+116 28.8	+9.3738	.9875	+0.7463	0.5172	.5492	+.1560	Western Territories.
5	55 Tauri	7	6 36.8	+ 50 00.7	+9.4445	.9825	+0.6155	0.7668	.5616	+.1275	N. E. States.
5	Rumk. 1167	7	8 09.8	+ 72 37.5	+9.4517	.9819	+0.7734	0.6699	.5616	+.1259	
5	63 Tauri	6	8 31.8	+ 77 58.6	+9.4514	.9819	+0.8126	0.7311	.5614	+.1259	
5	Lal. 8214	8	8 31.8	+ 77 57.5	+9.4475	.9822	+0.7943	0.8878	.5618	+.1259	Northern States.
5	δ^2 Tauri	4½	8 39.8	+ 79 49.4	+9.4682	.9804	+0.7233	0.0398	.5595	+.1259	S. W. Territories.
5	Lal. 8249	7½	8 51.8	+ 82 45.5	+9.4592	.9812	+0.7631	0.4491	.5610	+.1252	
5	Lal. 8256	8	8 51.8	+ 82 43.9	+9.4542	.9817	+0.7369	0.6543	.5615	+.1252	
6	B.A.C. 1647	7	9 31.8	+ 79 50.0	+9.5218	.9746	+0.7949	+0.1894	.5731	+.0826	Southern States.
6	B.A.C. 1651	6½	9 31.8	+ 79 40.7	+9.5268	.9739	+0.6399	−0.0597	.5721	+.0826	Mexico.
6	Lal. 10035	7½	10 36.8	+ 95 30.4	+9.5096	.9760	+0.8044	+0.8588	.5756	+.0807	
7	Lal. 11668	8	5 51.8	+ 13 21.2	+9.5445	.9716	+0.4755	0.3125	.5825	+.0410	Newfoundland.
7	15 Geminor	6	13 51.8	+129 09.6	+9.5518	.9705	+0.7600	0.1916	.5849	+.0236	Mexico.
7	16 Geminor	6	13 51.8	+129 06.8	+9.5459	.9714	+0.7161	0.4977	.5861	+.0236	Oregon & California.
7	ν Geminor	4	14 21.8	+136 22.5	+9.5402	.9721	+0.7603	0.7973	.5872	+.0224	Oregon.
7	B.A.C.2091	7	14 21.8	+136 19.9	+9.5518	.9705	+0.7165	0.2059	.5851	+.0224	California & Mexico.
8	ζ Geminor	4	2 27.8	− 50 25.0	+9.5500	.9708	−0.6049	0.4039	.5891	−.0045	
8	61 Geminor	7	14 03.8	+118 19.9	+9.5453	.9714	+0.7504	0.4325	.5913	−.0319	Western Territories.
9	d^1 Cancri	6	12 51.8	+ 87 06.1	+9.5083	.9762	+0.7049	0.8980	.5937	−.0825	Northern States.
9	θ Cancri	5½	16 21.8	+137 40.7	+9.5036	.9767	+0.8011	0.8095	.5932	−.0902	Oregon.
11	B.A.C. 3518	7½	11 51.8	+ 45 07.8	+9.3639	.9881	+0.5883	0.2498	.5832	−.1714	
12	B.A.C. 3837	6½	10 33.8	+ 12 35.9	+9.1882	.9948	+0.1528	0.4784	.5781	−.1998	
12	B.A.C. 3863	7	14 31.8	+ 70 23.3	+9.1128	.9963	+0.6048	1.0914	.5780	−.2037	Newfoundland.
12	B.A.C. 3871	7	15 36.8	+ 86 14.5	+9.1101	.9964	+0.7978	0.9166	.5776	−.2045	N. E. States.
13	*b* Virginis	5½	4 51.8	− 83 39.5	+8.8930	.9987	−0.6456	1.0311	.5744	−.2145	Newfoundland.
13	B.A.C. 4069	7	7 15.8	− 48 45.2	+8.8850	.9987	−0.4497	0.5958	.5733	−.2158	N. E. States.
13	B.A.C. 4116	7	12 36.8	+ 29 24.6	+8.7314	.9994	+0.3311	0.7377	.5725	−.2181	
17	θ Libræ	4½	10 31.8	− 52 44.5	−9.4479	.9822	−0.6745	1.2540	.5674	−.1553	Newfoundland.
17	49 Libræ	5½	14 21.8	+ 3 15.7	−9.4427	.9826	−0.1339	0.4706	.5696	−.1489	Southern States.
20	30 Sagittarii	6	17 06.8	+ 5 06.2	−9.5797	.9661	+0.0579	1.1267	.5572	−.0047	Northern States.
20	31 Sagittarii	6	17 36.8	+ 12 17.9	−9.5753	.9669	+0.0119	0.8694	.5583	−.0047	Western States.
23	30 Capricor.	6	12 31.8	− 97 48.3	−9.5038	.9767	−0.8624	0.8972	.5331	+.1125	Newfoundland
23	γ Capricor.	4	23 31.8	+ 62 05.6	−9.4741	.9798	−0.8718	0.8162	.5293	+.1276	Oregon & California.
24	39 Aquarii	7	16 21.8	− 52 51.7	−9.4109	.9851	−0.6841	0.4805	.5244	+.1484	
26	B.A.C. 8274	6½	18 21.8	− 44 55.8	−9.0984	.9965	−0.9290	0.5290	.5157	+.1907	California & Mexico.
May 2	Lal. 7646	8	7 36.8	+ 94 39.4	+9.4438	.9825	+0.8044	0.2721	.5614	+.1398	Southern States.
3	*m* Tauri	6	9 39.8	+111 40.2	+9.5001	.9771	+0.7854	0.9215	.5773	+.0958	N. W. Territories.
3	Lal. 9660	8	10 27.8	+123 14.8	+9.5074	.9763	+0.7951	0.6580	.5772	+.0939	Oregon & California.
4	χ^1 Orionis	5	5 21.8	+ 36 15.5	+9.5390	.9723	+0.7083	0.5305	.5848	+.0554	Newfoundland.
4	Lal. 11425	8	9 06.8	+ 90 29.1	+9.5460	.9713	+0.7820	0.3659	.5856	+.0467	
4	χ^4 Orionis	5	9 21.8	+ 94 02.7	+9.5368	.9726	+0.7355	0.8451	.5873	+.0467	
4	Lal. 11561	7½	10 51.8	+115 45.9	+9.5511	.9706	+0.7941	0.1842	.5853	+.0434	California & Mexico.
4	Lal. 11668	8	11 51.8	+130 12.7	+9.5445	.9716	+0.8054	0.5664	.5872	+.0412	Oregon & California.
4	Lal. 11717	7	12 21.8	+137 18.4	+9.5530	.9703	+0.6826	0.1466	.5856	+.0401	California & Mexico.
5	Lal. 13372	8	6 51.8	+ 44 12.3	+9.5574	.9697	+0.6066	0.2708	.5901	−.0018	Eastern States.
5	Lal. 13413	8	7 11.8	+ 48 58.3	+9.5476	.9711	+0.5682	0.7818	.5920	−.0024	
5	Lal. 13457	8	7 45.8	+ 57 12.4	+9.5597	.9693	+0.6237	0.1499	.5895	−.0041	Southern States.
5	Lal. 13471	8½	7 57.8	+ 60 03.7	+9.5590	.9694	+0.5940	0.1859	.5898	−.0041	
5	Lal. 13634	8	10 03.8	+ 90 30.7	+9.5505	.9707	+0.7449	0.6131	.5917	−.0087	
5	ζ Geminor	4	10 03.8	+ 90 30.5	+9.5500	.9708	+0.7420	0.6387	.5918	−.0087	
5	Lal. 13688	8	10 41.8	+ 99 38.5	+9.5586	9.9695	+0.7360	+0.1853	.5902	−.0110	California & Mexico.

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1851.	Star's Name.	Mag.	*T*	*H*	Log sin *D*	Log cos *D*	*p*	*q*	*p′*	*q′*	Where visible.
			h. m.	° ′							
May 5	Lal. 13778	8	11 51.8	+116 31.5	+9.5563	9.9699	+0.7878	+0.2940	.5907	—.0133	California & Mexico.
5	Lal. 13889	8	12 57.8	+132 17.7	+9.5443	.9716	+0.6955	0.8925	.5931	—.0156	Oregon
6	85 Geminor	6½	6 51.8	+ 30 26.0	+9.5397	.9722	+0.6291	0.4710	.5911	—.0568	Nova Scotia.
6	Lal. 15595	7	9 01.8	+ 61 44.2	+9.5386	.9724	+0.6753	0.3948	.5907	—.0613	
6	Lal. 15646	6½	9 36.8	+ 70 11.2	+9.5371	.9726	+0.7089	0.4347	.5907	—.0624	
6	Lal. 15861	8	12 09.8	+107 00.7	+9.5267	.9739	+0.7485	0.7727	.5916	—.0691	Oregon & California.
6	Lal. 16130	8	15 21.8	+153 10.5	+9.5159	.9753	+0.7480	1.0549	.5921	—.0757	Oregon.
7	δ Cancri	4½	0 36.8	— 74 53.7	+9.5059	.9764	—0.7340	0.7193	.5891	—.0950	
7	B.A.C. 3018	7½	6 21.8	+ 9 16.8	+9.4924	.9779	+0.4160	0.7386	.5876	—.1074	Newfoundland.
7	B.A.C. 3029	7	7 21.8	+ 23 56.0	+9.4851	.9787	+0.6304	0.9462	.5880	—.1094	Newfoundland.
7	B.A.C. 3041	7½	7 21.8	+ 23 35.5	+9.4911	.9781	+0.2987	0.6863	.5872	—.1094	Northern States.
7	68 Cancri	7	10 11.8	+ 64 57.3	+9.4820	.9790	+0.7504	0.7628	.5865	—.1154	
7	71 Cancri	7½	11 51.8	+ 89 01.0	+9.4895	.9782	+0.7504	0.2443	.5845	—.1183	Southern States.
7	B.A.C. 3103	7½	12 03.8	+ 91 53.8	+9.4831	.9789	+0.7442	0.4985	.5855	—.1183	
7	Lal. 18007	8	13 01.8	+105 51.1	+9.4733	.9799	+0.7454	+0.7932	.5861	—.1202	N. W. States.
7	78 Cancri	7	13 15.8	+109 15.1	+9.4915	.9780	+0.7727	—0.0146	.5832	—.1212	Mexico.
7	Lal. 18141	8	14 45.8	+130 53.8	+9.4692	.9803	+0.7656	+0.7511	.5853	—.1241	Oregon & California.
7	Lal. 18145	8½	14 51.8	+132 22.0	+9.4718	.9800	+0.7912	0.6326	.5849	—.1241	
8	34 Leonis	6	15 33.8	+129 05.8	+9.3863	.9867	+0.7249	0.2162	.5757	—.1659	California & Mexico.
9	B.A.C. 3837	6½	18 31.8	+159 02.3	+9.1882	.9948	+0.6798	0.5136	.5681	—.1989	Oregon.
10	B.A.C. 3996	6	9 01.8	+ 8 20.1	+9.0207	.9976	+0.1112	0.4091	.5644	—.2106	
10	B.A.C. 4021	7	11 36.8	+ 45 57.1	+8.9974	.9978	+0.3263	0.1796	.5638	—.2121	California & Mexico.
10	*b* Virginis	5½	14 51.8	+ 93 21.9	+8.8930	.9987	+0.6861	0.7163	.5636	—.2141	Oregon & California.
10	B.A.C. 4055	7	15 33.8	+103 35.1	+8.8907	.9987	+0.7705	0.5901	.5634	—.2143	Oregon & California.
10	B.A.C. 4069	7	17 09.8	+126 45.9	+8.8850	.9987	+0.7836	0.3049	.5627	—.2153	Oregon & California.
12	80 Virginis	6	8 27.8	— 24 47.5	—8.9076	.9986	+0.0211	0.8153	.5608	—.2169	Newfoundland.
12	B.A.C. 4593	7	15 09.8	+ 73 00.9	—9.0163	.9976	+0.7910	0.7107	.5612	—.2136	
12	*n* Virginis	7	15 33.8	+ 78 49.0	—9.0259	.9975	+0.7984	0.7601	.5612	—.2137	
13	B.A.C. 4794	7	7 01.8	— 58 34.0	—9.2100	.9942	—0.5761	0.8236	.5640	—.2029	Nova Scotia.
13	B.A.C. 4837	7	12 27.8	+ 20 33.1	—9.2358	.9935	—0.1253	0.3224	.5644	—.1979	Mexico.
14	η Libræ	4½	18 33.8	+ 97 06.7	—9.4184	.9845	+0.7814	0.3101	.5692	—.1601	Mexico.
15	χ Ophiuchi	5	11 15.8	— 22 22.6	—9.4926	.9779	—0.2785	0.8886	.5698	—.1321	
17	14 Sagittarii	6	8 39.8	— 86 14.5	—9.5688	.9679	—0.7268	0.6933	.5685	—.0432	N. E. States.
18	50 Sagittarii	6	17 51.8	+ 35 05.6	—9.5749	.9669	+0.0927	0.7761	.5585	+.0255	Oregon & California.
20	20 Capricor.	6	12 01.8	— 74 06.0	—9.5258	.9740	—0.5656	0.8217	.5396	+.1003	N. E. States.
June 1	Lal. 12772	8½	6 51.8	+ 74 50.6	+9.5558	.9699	+0.6779	0.4603	.5969	+.0147	N. E. States.
1	Lal. 12786	8	7 06.8	+ 78 30.7	+9.5499	.9708	+0.7420	0.7645	.5984	+.0141	N. E. States.
1	Lal. 12914	7	8 31.8	+ 98 57.6	+9.5511	.9706	+0.7668	0.7211	.5983	+.0109	
1	Lal. 12933	7	8 39.8	+100 52.1	+9.5545	.9701	+0.7528	0.5507	.5976	+.0109	
1	Lal. 12983	9	9 11.8	+108 30.2	+9.5515	.9706	+0.7032	0.7070	.5985	+.0088	N. W. Territories.
1	Lal. 13065	8	10 21.8	+125 25.2	+9.5489	.9709	+0.7976	0.8511	.5991	+.0064	N. W. Territories.
2	Lal. 15007	7	8 21.8	+ 82 28.7	+9.5500	.9708	+0.7791	0.3516	.5976	—.0462	
2	79 Geminor	7	8 41.8	+ 87 15.5	+9.5477	.9711	+0.7556	0.4479	.5979	—.0473	
2	Lal. 15244	8½	10 57.8	+119 54.3	+9.5504	.9707	+0.7345	0.2058	.5968	—.0520	California & Mexico.
2	Lal. 15323	9	11 51.8	+132 54.0	+9.5456	.9714	+0.7572	0.3998	.5973	—.0544	Oregon & California.
2	85 Geminor	6½	12 51.8	+147 17.4	+9.5397	.9722	+0.7350	0.6390	.5980	—.0567	Oregon.
3	Lal. 17148	8½	8 03.8	+ 64 09.2	+9.5056	.9765	+0.7809	0.7425	.5932	—.0990	N. E. States.
3	δ Cancri	4½	8 33.8	+ 71 17.7	+9.5059	.9764	+0.7130	0.6769	.5929	—.1002	
3	Lal. 17317	9	10 11.8	+ 94 55.3	+9.4946	.9777	+0.7795	1.0134	.5948	—.1045	Canada.
3	B.A.C. 2990	7	10 57.8	+105 52.9	+9.5027	.9768	+0.6831	0.5765	.5920	—.1055	
3	Lal. 17410	9	11 11.8	+109 19.2	+9.5034	.9767	+0.7532	0.5177	.5913	—.1065	Western Territories.
3	Lal. 17428	8½	11 21.8	+111 41.3	+9.4971	.9774	+0.7198	0.7807	.5922	—.1065	Western Territories.
3	Lal. 17462	7½	11 51.8	+118 56.6	+9.5071	.9763	+0.7580	0.2822	.5905	—.1076	Western Territories.
3	B.A.C. 3015	7	12 09.8	+123 17.5	+9.4883	.9784	+0.7809	1.0822	.5933	—.1076	Oregon.
3	B.A.C. 3018	7½	12 21.8	+126 08.4	+9.4924	9.9779	+0.7446	+0.8800	.5922	—.1086	Oregon.

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1851.	Star's Name.	Mag.	T	H	Log sin D	Log cos D	p	q	p'	q'	Where visible.
			h. m.	° ′							
June 3	B.A.C. 3041	7½	13 21.8	+140 27.1	+9.4911	9.9781	+0.6343	+0.8264	.5918	−.1107	Oregon.
4	Lal. 19242	8	11 21.8	+ 98 10.3	+9.4311	.9836	+0.7766	0.3527	.5816	−.1499	Western Territories.
4	Lal. 19264	9	11 39.8	+102 29.9	+9.4202	.9844	+0.7709	0.7088	.5818	−.1515	Western Territories.
4	Lal. 19371	7½	13 15.8	+125 35.6	+9.4251	.9840	+0.7528	0.2819	.5796	−.1548	California & Mexico.
5	B.A.C. 3662	7½	9 39.8	+ 60 24.0	+9.3002	.9912	+0.6739	0.7863	.5715	−.1838	
5	656 Hora 10	8	11 03.8	+ 80 46.1	+9.2866	.9917	+0.7903	0.8908	.5712	−.1849	N. E. States.
5	712 Hora 10	8	12 31.8	+101 59.3	+9.2893	9916	+0.7923	0.5473	.5698	−.1867	Western States.
5	741 Hora 10	8	13 03.8	+109 41.2	+9.2783	.9920	+0.7770	0.7340	.5700	−.1873	Oregon & California.
6	B.A.C. 3947	7	10 31.8	+ 60 28.2	+9.0916	.9967	+0.8217	0.3791	.5610	−.2070	
8	80 Virginis	6	16 21.8	+120 38.7	−8.9077	.9986	+0.7528	0.6936	.5531	−.2149	California & Mexico.
9	B.A.C. 4794	7	16 39.8	+112 56.5	−9.2100	.9942	+0.7930	0.4492	.5558	−.2000	California & Mexico.
12	B.A.C. 5700	6½	8 03.8	− 50 23.4	−9.5192	.9749	−0.5891	0.6200	.5683	−.1110	
12	B.A.C. 5746	7	13 11.8	+ 24 55.1	−9.5399	.9722	+0.4424	1.1122	.5674	−.1006	Canada.
12	B.A.C. 5784	7	16 21.8	+ 70 58.3	−9.5435	.9717	+0.6833	0.9895	.5681	−.0948	
14	28 Sagittarii	6	7 11.8	− 88 42.9	−9.5836	.9655	−0.7483	1.0649	.5656	−.0147	Newfoundland.
14	31 Sagittarii	6	10 03.8	− 47 03.3	−9.5753	.9669	−0.5738	0.5471	.5668	−.0085	
14	ο Sagittarii	4½	17 51.3	+ 67 07.5	−9.5727	.9673	+0.7140	0.3925	.5655	+.0070	Southern States.
17	γ Capricor.	4	17 41.8	+ 28 33.5	−9.4740	.9798	+0.4065	0.6567	.5326	+.1319	
17	δ Capricor.	3½	21 51.8	+ 89 29.0	−9.4609	.9811	+0.7856	0.6310	.5309	+.1371	California & Mexico.
24	ξ² Ceti	4	1 21.8	+ 77 41.3	+9.1320	.9960	+0.8008	1.0750	.5320	+.1910	N. W. Territories.
30	Lal. 16516	9	8 33.8	+102 32.4	+9.5197	.9748	+0.7271	0.7984	.6045	−.0843	
30	Lal. 16678	8	10 21.8	+128 24.7	+9.5227	.9744	+0.6764	0.5015	.6028	−.0890	Oregon & California.
30	B.A.C. 2854	6½	10 41.8	+133 15.3	+9.5210	.9746	+0.7178	0.4507	.6028	−.0901	Oregon & California.
30	Lal. 16807	8	11 51.8	+150 07.0	+9.5105	.9759	+0.7752	0.9292	.6041	−.0924	Oregon.
July 1	B.A.C. 3209	7	8 15.8	+ 84 06.3	+9.4714	.9801	+0.7847	0.2699	.5933	−.1356	Southern States.
1	Lal. 18743	8	11 03.8	+124 25.8	+9.4513	.9819	+0.7379	0.6850	.5931	−.1413	Oregon & California.
1	Lal. 18886	8	13 01.8	+152 50.1	+9.4382	.9830	+0.7773	0.9078	.5928	−.1450	Oregon.
1	Lal. 18895	9	13 01.8	+152 45.3	+9.4436	.9826	+0.7000	0.7006	.5922	−.1450	Oregon & California.
2	237 Hora 10	9	7 27.8	+ 58 51.0	+9.3578	.9884	+0.7394	0.7034	.5825	−.1742	Nova Scotia.
2	285 Hora 10	8½	8 39.8	+ 76 10.2	+9.3676	.9879	+0.7249	0.1876	.5808	−.1756	Southern States.
2	323 Hora 10	8½	9 27.8	+ 87 46.6	+9.3600	.9883	+0.7761	0.2857	.5804	−.1770	
2	334 Hora 10	8½	9 41.8	+ 91 08.1	+9.3586	.9884	+0.7638	0.2861	.5801	−.1777	
2	378 Hora 10	8	10 33.8	+103 37.5	+9.3503	.9888	+0.7352	0.3866	.5802	−.1784	Western States.
2	399 Hora 10	8½	10 51.8	+107 54.2	+9.3316	.9898	+0.6823	0.8898	.5810	−.1791	N. W. Territories.
2	492 Hora 10	9	13 15.8	+142 38.3	+9.3226	.9902	+0.7410	0.7143	.5790	−.1823	Oregon & California.
2	496 Hora 10	9	13 15.8	+142 35.6	+9.3195	.9903	+0.6965	0.8017	.5792	−.1823	Oregon & California.
2	499 Hora 10	8	13 15.8	+142 18.6	+9.3313	.9898	+0.6634	0.4649	.5785	−.1823	Oregon & California.
3	319 Hora 11	9	11 06.8	+ 98 38.5	+9.1554	.9955	+0.7854	0.3934	.5669	−.2051	Western Territories.
3	361 Hora 11	9	12 03.8	+112 23.2	+9.1359	.9959	+0.7823	0.5630	.5666	−.2058	Western Territories.
3	387 Hora 11	9	12 31.8	+119 03.5	+9.1449	.9957	+0.7000	0.3008	.5664	−.2058	California & Mexico.
3	395 Hora 11	9	13 01.8	+126 24.0	+9.1248	.9961	+0.8056	0.5647	.5666	−.2062	California & Mexico.
3	472 Hora 11	9	14 51.8	+152 50.8	+9.0920	.9966	+0.7191	0.7501	.5657	−.2076	Oregon.
4	269 Hora 12	8	13 21.8	+118 49.6	+8.5854	.9997	+0.8350	0.8876	.5571	−.2180	Oregon.
7	ξ¹ Libræ	6	9 09.8	+ 21 18.1	−9.2917	.9915	+0.3247	0.4681	.5527	−.1882	
8	η Libræ	4½	6 36.8	− 28 25.1	−9.4184	.9845	−0.3612	0.7642	.5559	−.1626	
8	θ Libræ	4½	12 51.8	+ 63 10.5	−9.4479	.9822	+0.6855	0.9247	.5569	−.1533	
9	B.A.C. 5700	6½	17 09.8	+113 05.8	−9.5192	.9749	+0.7542	0.4067	.5589	−.1048	California.
10	58 Ophiuchi	5	12 51.8	+ 37 51.4	−9.5661	.9684	+0.3667	1.1424	.5638	−.0683	N. W. Territories.
11	28 Sagittarii	6	17 03.8	+ 86 18.1	−9.5836	.9655	+0.6583	1.0406	.5629	−.0111	N. W. Territories.
12	50 Sagittarii	6	8 36.8	− 49 49.6	−9.5749	.9669	−0.6162	0.6166	.5614	+.0205	
20	B. A. C. 612	7	17 39.8	− 4 30.3	+8.9665	.9981	−0.0752	0.5981	.5195	+.1976	
21	B. A. C. 845	4	15 36.8	− 45 31.7	+9.2168	.9940	−0.6080	0.2782	.5281	+.1858	
22	*f* Tauri	5½	13 39.8	− 85 19.1	+9.3327	.9897	−0.8249	1.0151	.5435	+.1671	Northern States.
23	55 Tauri	7	12 21.8	−116 04.3	+9.4446	.9825	−0.7572	0.5347	.5604	+.1386	N. E. States.
23	63 Tauri	6	13 51.8	− 94 22.8	+9.4515	9.9819	−0.7918	+0.4610	.5614	+.1365	

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1851.	Star's Name.	Mag.	T	H	Log sin D	Log cos D	p	q	p'	q'	Where visible.
			h. m.	° ′							
July 23	B.A.C. 1351	6½	13 51.8	− 94 23.8	+9.4476	9.9822	−0.8082	+0.6166	.5618	+.1365	
25	15 Geminor	6	17 51.8	− 63 15.0	+9.5519	.9705	−0.7332	0.4866	.5991	+.0344	S. W. Territories.
25	16 Geminor	6	18 06.8	− 59 32.2	+9.5459	.9714	−0.6292	0.7956	.6002	+.0344	N. W. Territories.
25	B.A.C. 2091	7	18 36.8	− 52 19.0	+9.5518	.9705	−0.6131	0.5144	.5994	+.0332	Oregon & California.
29	Lal. 19572	9	7 31.8	+ 91 39.9	+9.4026	.9857	+0.7551	0.6787	.5974	−.1638	N. E. States.
29	Lal. 19656	8	8 51.8	+110 57.0	+9.3931	.9863	+0.8147	0.7793	.5955	−.1660	N. W. Territories.
30	909 Hora 10	9	6 39.8	+ 65 24.6	+9.2592	.9927	+0.7283	0.6065	.5833	−.1968	Newfoundland.
30	914 Hora 10	8	6 51.8	+ 68 20.9	+9.2604	.9927	+0.7775	0.5381	.5832	−.1969	Newfoundland.
30	987 Hora 10	8	8 39.8	+ 94 19.8	+9.2384	.9934	+0.7654	0.7005	.5821	−.1995	
30	1094 Hora 10	8½	10 51.8	+126 01.8	+9.2321	.9936	+0.6909	0.4029	.5805	−.2011	California & Mexico.
30	40 Hora 11	9	12 21.8	+147 46.1	+9.1979	.9945	+0.7600	0.8433	.5805	−.2026	Oregon.
31	866 Hora 11	9	8 21.8	+ 76 53.8	+8.9556	.9982	+0.7635	0.4959	.5698	−.2171	
31	875 Hora 11	9	8 31.8	+ 79 17.2	+8.9547	.9982	+0.7439	0.4702	.5699	−.2172	
31	913 Hora 11	8½	9 21.8	+ 91 18.9	+8.9339	.9984	+0.7180	0.5310	.5695	−.2176	
31	1038 Hora 11	8½	13 01.8	+144 25.2	+8.8364	9.9990	+0.7741	0.7186	.5681	−.2191	Oregon.
Aug. 1	736 Hora 12	8½	7 39.8	+ 54 10.8	+7.0139	0.0000	+0.7965	0.4764	.5610	−.2221	Newfoundland.
1	781 Hora 12	8½	8 45.8	+ 70 02.5	+6.8731	0.0000	+0.7273	0.2489	.5604	−.2219	Southern States.
1	819 Hora 12	8	9 51.8	+ 85 59.8	−8.2027	9.9999	+0.7919	0.9663	.5599	−.2216	Northern States.
1	835 Hora 12	7	9 51.8	+ 85 48.2	−7.4074	0.0000	+0.5981	0.1949	.5601	−.2218	California & Mexico.
1	847 Hora 12	9	10 15.8	+ 91 41.8	−7.7190	0.0000	+0.6981	0.2610	.5599	−.2217	California & Mexico.
2	644 Hora 13	7½	7 51.8	+ 44 39.0	−8.9619	9.9982	+ 0.6637	0.5421	.5553	−.2145	N. E. States.
2	n Virginis	7	9 31.8	+ 68 53.4	−9.0260	.9975	+0.7490	1.0375	.5544	−.2136	Lower Canada.
2	756 Hora 13	8	11 09.8	+ 92 35.9	−9.0495	.9972	+0.7878	1.0363	.5541	−.2125	N. W. Territories.
3	B.A.C. 4837	7	8 01.8	+ 34 41.4	−9.2358	.9935	+0.4393	0.3237	.5541	−.1960	Southern States.
4	γ Libræ	4½	9 11.8	+ 39 10.6	−9.3924	.9863	+0.1899	0.2835	.5558	−.1658	Mexico.
4	B.A.C. 5184	7	13 31.8	+102 33.2	−9.4278	.9838	+0.7789	0.8776	.5547	−.1602	N. W Territories.
4	η Libræ	4½	14 09.8	+111 45.3	−9.4184	.9845	+0.8054	0.4207	.5560	−.1587	California & Mexico.
5	χ Ophiuchi	5	8 21.8	+ 14 49.7	−9.4926	.9779	+0.2068	0.8466	.5572	−.1306	
7	14 Sagittarii	6	7 27.8	− 23 28.2	−9.5688	.9679	−0.1325	0.5933	.5613	−.0424	Nova Scotia.
8	o Sagittarii	4½	4 51.8	− 74 12.0	−9.5727	.9673	−0.7651	0.3780	.5604	+.0011	Southern States.
8	B.A.C. 6524	6½	6 41.8	− 47 11.3	−9.5868	.9649	−0.3411	1.2167	.5569	+.0051	Newfoundland.
8	B.A.C. 6561	6	11 01.8	+ 16 36.1	−9.5717	.9675	+0.7218	0.3653	.5595	+.0131	Southern States.
8	B.A.C. 6607	6	13 21.8	+ 49 39.7	−9.5860	.9651	−0.0271	1.2462	.5556	+.0181	N. W. Territories.
8	B.A.C. 6638	6	17 21.8	+108 23.6	−9.5749	.9669	+0.7587	0.6772	.5569	+.0260	Western Territories.
9	B.A.C. 6889	6	9 33.8	− 17 37.9	−9.5684	.9680	−0.0734	0.9826	.5517	+.0567	
10	20 Capricor.	6	11 15.8	− 4 48.6	−9.5258	.9740	−0.1045	0.7127	.5431	+.1018	
13	ψ^3 Aquarii	5	8 27.8	− 78 59.3	−9.2573	.9928	−0.8574	0.7104	.5163	+.1819	
17	ξ^2 Ceti	4	15 06.8	− 22 16.7	+9.1322	.9960	−0.3239	0.7166	.5208	+.1891	
18	B. A. C. 845	4	1 51.8	+135 15.0	+9.2169	.9940	+0.8110	0.8660	.5257	+.1823	Oregon.
20	δ^2 Tauri	4½	1 36.8	+108 48.5	+9.4683	.9804	+0.8033	0.2639	.5553	+.1302	California & Mexico.
20	m Tauri	5½	18 11.8	− 12 33.0	+9.5001	.9771	−0.7055	0.7704	.5698	+.1023	Oregon.
21	χ^1 Orionis	5	14 01.8	− 85 57.4	+9.5391	.9723	−0.7739	0.5431	.5829	+.0641	
21	χ^4 Orionis	5	17 51.8	− 30 40.6	+9.5369	.9726	−0.8364	0.8810	.5871	+.0555	Oregon.
23	85 Geminor	6½	14 27.8	−107 49.5	+9.5397	.9722	−0.7416	0.8602	.6069	−.0508	Nova Scotia.
24	B.A.C. 3058	7	15 09.8	−112 15.5	+9.5062	.9764	−0.7107	0.3753	.6056	−.1111	Southern States.
24	71 Cancri	7½	17 51.8	− 73 18.3	+9.4895	.9782	−0.6336	0.8158	.6067	−.1167	N. W. Territories.
24	78 Cancri	7	19 01.8	− 56 34.8	+9.4916	.9780	−0.6985	0.5888	.6056	−.1189	Oregon.
28	356 Hora 12	9	7 01.8	+ 76 42.9	+8.5373	.9997	+0.7752	0.6163	.5737	−.2262	N. E. States.
28	515 Hora 12	8½	11 09.8	+136 28.7	+8.2562	.9999	+0.7736	0.6091	.5721	−.2268	Oregon.
29	298 Hora 13	9	8 01.8	+ 78 20.3	−8.8069	.9991	+0.7741	0.5691	.5664	−.2230	
29	299 Hora 13	9½	8 01.8	+ 78 19.6	−8.8249	.9990	+0.7635	0.7244	.5662	−.2230	
29	307 Hora 13	9	8 06.8	+ 79 32.7	−8.8269	.9990	+0.7757	0.7238	.5662	−.2230	
29	321 Hora 13	9	8 27.8	+ 84 34.2	−8.8644	.9988	+0.7354	0.9922	.5658	−.2228	Northern States.
30	179 Hora 14	9	6 45.8	+ 47 20.8	−9.1808	.9949	+0.7362	0.7163	.5622	−.2075	Newfoundland.
30	189 Hora 14	9	6 51.8	+ 48 44.8	−9.1684	9.9952	+0.6898	+0.4458	.5626	−.2075	N. E. States.

For facilitating the Computation of such Occultations of Planets and Stars by the Moon *as will be visible in North America during the year* 1851.

1851.	Star's Name.	Mag.	T	H	Log sin D	Log cos D	p	q	p'	q'	Where visible.
			h. m.	° ′							
Aug 30	252 Hora 14	9	8 21.8	+ 70 28.2	−9.2045	9.9943	+0.6973	+0.8845	.5617	−.2061	
30	353 Hora 14	9	10 51.8	+106 47.0	−9.2192	.9939	+0.8181	0.6958	.5618	−.2037	Western Territories.
30	B.A.C. 4794	7	11 15.8	+112 32.4	−9.2101	.9942	+0.7841	0.4125	.5623	−.2032	S. W. Territories.
30	395 Hora 14	9	11 41.8	+118 48.9	−9.2169	.9940	+0.7856	0.4749	.5622	−.2032	California & Mexico.
31	79 Hora 15	7½	6 51.8	+ 36 05.9	−9.3671	.9879	+0.5814	0.8462	.5605	−.1805	N. E. States.
31	85 Hora 15	9	6 51.8	+ 36 01.8	−9.3565	.9885	+0.5129	0.5089	.5613	−.1805	Eastern States.
31	91 Hora 15	7	6 51.8	+ 35 58.3	−9.3730	.9875	+0.4532	1.0380	.5600	−.1805	
31	185 Hora 15	8	9 33.8	+ 75 23.5	−9.3771	.9873	+0.7823	0.6942	.5608	−.1770	
31	199 Hora 15	9	9 51.8	+ 79 41.5	−9.3793	.9872	+0.7396	0.7140	.5608	−.1764	
31	215 Hora 15	9	10 11.8	+ 84 32.4	−9.3897	.9865	+0.7605	1.0083	.5600	−.1757	N. W. Territories.
31	241 Hora 15	9	10 51.8	+ 94 12.3	−9.3829	.9869	+0.7755	0.6593	.5608	−.1750	Western Territories.
31	249 Hora 15	9	11 01.8	+ 96 34.5	−9.3940	.9862	+0.7325	1.0095	.5600	−.1751	Oregon.
31	265 Hora 15	8	11 27.8	+102 52.4	−9.3780	.9872	+0.7580	0.3919	.6030	−.1743	California & Mexico.
Sept. 1	Lal. 29452	8	8 27.8	+ 46 52.1	−9.4835	.9789	+0.7386	1.1128	.5600	−.1419	Newfoundland.
2	B.A.C. 5746	7	6 51.8	+ 10 28.7	−9.5399	.9722	+0.1110	1.0747	.5604	−.1014	N. E. States.
3	B.A.C. 6064	7	5 27.8	− 22 27.6	−9.5723	.9674	+0.0370	1.0406	.5598	−.0572	Newfoundland.
4	B.A.C. 6524	6½	14 09.8	+ 91 43.8	−9.5868	.9649	+0.7099	1.1249	.5545	+.0096	Oregon.
7	γ Capricor.	4	14 36.8	+ 62 59.9	−9.4740	.9798	+0.7393	0.6860	.5323	+.1336	
7	δ Capricor.	3½	17 51.8	+110 08.2	−9.4609	.9811	+0.6214	0.5386	.5314	+.1381	California & Mexico.
8	B.A.C. 7835	6½	16 09.8	+ 74 44.6	−9.3736	.9875	+0.8220	0.4529	.5232	+.1642	
9	ψ¹ Aquarii	5½	16 09.8	+ 64 13.2	−9.2351	.9935	+0.7816	0.4500	.5161	+.1847	
9	ψ² Aquarii	5	17 27.8	+ 83 15.3	−9.2393	.9934	+0.8831	0.7985	.5156	+.1854	
9	B.A.C. 8154	7	20 33.8	+128 24.9	−9.2072	.9943	+0.8710	0.5790	.5151	+.1874	Oregon.
18	15 Geminor	6	12 03.8	− 96 16.9	+9.5519	.9705	−0.7637	0.7561	.5826	+.0328	
18	B.A.C. 2091	7	12 41.8	− 87 06.2	+9.5518	.9705	−0.7321	0.7786	.5834	+.0306	
20	B.A.C. 2854	6½	14 15.8	− 92 16.7	+9.5231	.9744	−0.7615	0.8354	.5988	−.0857	
20	B.A.C. 2899	7	16 51.8	− 54 41.7	+9.5294	.9736	−0.6507	0.3061	.5969	−.0915	
21	8 Leonis	6½	16 21.8	− 76 07.6	+9.4684	.9804	−0.7665	0.2138	.5963	−.1430	Southern States.
28	θ Libræ	4½	9 15.8	+ 89 51.3	−9.4478	.9822	+0.7681	0.5144	.5709	−.1575	
28	Lal. 29052	8	11 33.8	+123 04.8	−9.4624	.9809	+0.7404	0.7416	.5702	−.1541	Oregon.
29	B.A.C. 5580	7	5 21.8	+ 20 13.5	−9.5264	.9740	+0.5498	1.1556	.5683	−.1210	Newfoundland.
29	Lal. 30479	8	7 41.8	+ 54 03.7	−9.5303	.9735	+0.6503	1.0720	.5685	−.1161	Canadas.
29	Lal. 30506	9	8 03.8	+ 59 21.7	−9.5257	.9741	+0.6492	0.8024	.5694	−.1161	
29	Lal. 30533	9	8 21.8	+ 63 37.7	−9.5298	.9735	+0.5798	0.9689	.5687	−.1151	Northern States.
29	Lal. 30600	9	9 31.8	+ 80 38.5	−9.5252	.9741	+0.7239	0.6093	.5699	−.1131	Western Territories.
29	B.A.C. 5663	6½	10 33.8	+ 95 33.9	−9.5375	.9725	+0.7073	1.1026	.5681	−.1112	Oregon.
30	B.A.C. 5954	6	5 27.8	+ 8 32.9	−9.5702	.9677	+0.4248	1.1125	.5660	−.0723	Newfoundland.
30	58 Ophiuchi	5	7 33.8	+ 38 57.9	−9.5661	.9684	+0.4730	0.7411	.5671	−.0681	
30	Lal. 32309	9	8 21.8	+ 50 41.1	−9.5727	.9673	+0.6187	1.0541	.5657	−.0660	Northern States.
Oct. 1	28 Sagittarii	6	11 27.8	+ 82 53.5	−9.5836	.9655	+0.7777	0.6806	.5613	−.0090	Western Territories.
1	B.A.C. 6400	7	12 51.8	+102 58.9	−9.5922	.9640	+0.6053	1.1803	.5589	−.0059	Oregon.
1	30 Sagittarii	6	13 21.8	+110 20.3	−9.5796	.9661	+0.7261	0.4381	.5616	−.0048	California & Mexico.
1	31 Sagittarii	6	14 03.8	+120 32.5	−9.5753	.9669	+0.7980	0.1856	.5621	−.0027	California & Mexico.
3	B.A.C. 7102	7½	13 27.8	+ 87 19.9	−9.5562	.9699	+0.5703	1.1698	.5404	+.0872	Oregon.
6	74 Aquarii	6	8 15.8	− 22 22.7	−9.3320	.9897	−0.3200	0.6384	.5175	+.1749	
7	B.A.C. 8274	6½	15 57.8	+ 80 36.7	−9.0982	.9965	+0.8580	0.7850	.5111	+.1968	
11	B. A. C. 845	4	11 51.8	− 21 07.2	+9.2169	.9940	−0.3006	0.8435	.5253	+.1869	Canada.
13	δ¹ Tauri	4	11 36.8	− 47 16.3	+9.4706	.9801	−0.3830	0.2630	.5474	+.1343	Eastern States.
13	δ² Tauri	4½	11 51.8	− 43 48.1	+9.4683	.9804	−0.5464	0.3981	.5484	+.1335	
16	63 Geminor	6	20 45.8	+ 47 10.4	+9.5687	.9679	+0.0974	0.1916	.5828	−.0244	Oregon.
18	80 Cancri	6½	14 36.8	− 69 31.6	+9.5048	.9766	−0.7191	0.2254	.5851	−.1203	Southern States.
18	83 Cancri	6	17 51.8	− 22 24.9	+9.4976	.9774	−0.5255	0.1444	.5844	−.1276	S. W. Territories.
19	37 Leonis	6	17 51.8	− 35 56.0	+9.3976	.9860	−0.5623	0.4267	.5816	−.1720	Western Territories.
20	B.A.C. 3759	8	11 51.8	−135 58.0	+9.2697	.9923	−0.6255	0.8162	.5790	−.1986	Newfoundland.
26	B.A.C. 5408	7	4 03.8	+ 34 03.0	−9.4934	9.9778	+0.6837	+0.8954	.5780	−.1457	Newfoundland.

For facilitating the Computation of such Occultations of Planets and Stars by the Moon *as will be visible in North America during the year* 1851.

1851.	Star's Name.	Mag.	*T*	*H*	Log sin *D*	Log cos *D*	*p*	*q*	*p′*	*q′*	Where visible.
			h. m.	° ′							
Oct 26	Lal. 29618	8	4 51.8	+ 45 40.4	−9.4951	9.9776	+0.7516	+0.8543	.5781	−.1448	Newfoundland.
26	Lal. 29696	7	6 06.8	+ 63 39.9	−9.5007	.9770	+0.6933	0.9219	.5780	−.1419	
26	Lal. 29725	8	6 21.8	+ 67 11.8	−9.4976	.9774	+0.6180	0.7490	.5786	−.1419	Western Territories.
26	χ Ophiuchi	5	9 21.8	+110 41.8	−9.4926	.9779	+0.7892	0.1120	.5808	−.1360	Mexico.
27	Lal. 31307	8	4 51.8	+ 32 04.9	−9.5502	.9707	+0.5853	0.5962	.5784	−.0955	Nova Scotia.
27	ξ Ophiuchi	4½	7 06.8	+ 64 25.1	−9.5533	.9703	+0.4354	0.5450	.5784	−.0901	California & Mexico.
27	B.A.C. 5866	6	9 06.8	+ 93 33.8	−9.5602	.9693	+0.6872	0.7348	.5773	−.0857	Western Territories.
27	B.A.C. 5880	7	10 03.8	+107 21.1	−9.5608	.9692	+0.7537	0.6899	.5774	−.0835	Western Territories.
28	Lal. 33590	8	7 15.8	+ 53 26.6	−9.5799	.9661	+0.6150	0.4613	.5737	−.0367	
28	Lal. 33651	9	7 51.8	+ 62 07.2	−9.5881	.9647	+0.6196	0.9145	.5719	−.0355	
28	Lal. 33767	8	9 11.8	+ 81 28.7	−9.5802	.9661	+0.7107	0.4131	.5735	−.0322	California & Mexico.
28	Lal. 33769	8	9 11.8	+ 81 27.1	−9.5792	.9662	+0.6850	0.5288	.5736	−.0322	California & Mexico.
29	Lal. 35988	8	6 51.8	+ 34 28.0	−9.5885	.9646	+0.4536	0.7130	.5643	+.0149	
29	B.A.C. 6607	6	10 27.8	+ 86 51.7	−9.5860	.9651	+0.7607	0.6361	.5632	+.0224	Western Territories.
29	Lal. 36504	9	12 01.8	+109 30.8	−9.5892	.9645	+0.7430	0.8664	.5616	+.0253	Oregon & California.
29	Lal. 36507	8½	12 01.8	+109 29.1	−9.5901	.9643	+0.7155	0.9181	.5613	+.0253	Oregon & California.
29	Lal. 36516	8	12 11.8	+111 56.0	−9.5893	.9645	+0.7509	0.8720	.5613	+.0277	Oregon & California.
29	Lal. 36562	7½	12 41.8	+119 10.8	−9.5871	.9649	+0.7630	0.7565	.5617	+.0275	Oregon & California.
30	Lal. 38357	8	6 21.8	+ 14 38.9	−9.5752	.9669	+0.4335	0.8700	.5526	+.0626	Nova Scotia.
30	Lal. 38839	7½	11 41.8	+ 92 13.6	−9.5692	.9679	+0.7274	0.8839	.5495	+.0729	Oregon & California.
31	B.A.C. 7330	7	11 21.8	+ 75 31.9	−9.5273	.9739	+0.7291	0.8291	.5376	+.1129	Western Territories.
Nov. 1	B.A.C. 7601	7	6 51.8	− 1 54.5	−9.4789	.9793	−0.0482	0.9618	.5276	+.1408	
3	ψ³ Aquarii	5	3 51.8	− 67 21.3	−9.2574	.9928	−0.5853	0.5603	.5124	+.1865	Newfoundland.
3	B.A.C. 8214	6½	15 41.8	+106 28.2	−9.1586	9.9954	+0.9103	0.4446	.5101	+.1940	California & Mexico.
5	26 Ceti	6½	15 31.8	+ 83 51.5	+7.9983	0.0000	+0.8968	0.3842	.5103	+.2084	
7	ξ² Ceti	4	8 41.8	− 37 58.5	+9.1322	9.9960	−0.8817	0.8630	.5230	+.1967	Oregon.
7	B. A. C. 826	7	19 06.8	+115 15.9	+9.2357	.9935	+0.8859	0.5666	.5280	+.1894	Oregon & California.
7	B. A. C. 830	6	19 21.8	+118 54.4	+9.2442	.9932	+0.9076	0.4044	.5373	+.1929	Oregon & California.
9	δ¹ Tauri	4	19 41.8	+100 55.3	+9.4706	.9801	+0.7949	0.6952	.5545	+.1335	
9	δ² Tauri	4½	20 21.8	+110 39.4	+9.4683	.9804	+0.8682	0.8847	.5551	+.1330	Western States.
9	δ³ Tauri	5	20 51.8	+117 50.2	+9.4802	.9792	+0.7941	0.4270	.5542	+.1319	Oregon & California.
10	*i* Tauri	5½	5 51.8	−113 14.4	+9.5033	.9767	−0.7499	0.4804	.5592	+.1171	Eastern States.
12	*d* Geminor	6	9 45.8	− 82 35.9	+9.5723	.9674	−0.7607	0.3777	.5800	+.0109	
15	26 Leonis	7	17 06.8	− 15 57.4	+9.4385	.9830	−0.2154	0.4009	.5736	−.1584	
17	ν Virginis	4½	15 11.8	− 69 50.0	+9.1076	.9964	−0.8019	0.2857	.5634	−.2166	Southern States.
19	B.A.C. 4572	7	20 15.8	− 21 09.0	−8.9181	.9985	−0.4483	0.3443	.5649	−.2275	California & Mexico.
20	B.A.C. 4837	7	19 51.8	− 39 53.6	−9.2359	.9935	−0.6714	0.3314	.5704	−.2111	California & Mexico.
24	B.A.C. 5992	7	3 21.8	+ 29 46.0	−9.5759	.9668	+0.6378	0.8087	.5818	−.0708	Newfoundland.
24	Lal. 32309	9	3 36.8	+ 33 26.9	−9.5727	.9673	+0.7088	0.6133	.5826	−.0708	Nova Scotia.
24	Lal. 32424	6½	4 41.8	+ 48 59.1	−9.5813	.9659	+0.6107	1.0219	.5809	−.0674	N. E. States.
24	Lal. 32584	7½	6 41.8	+ 77 55.9	−9.5851	.9652	+0.6853	1.1069	.5801	−.0627	N. W. Territories.
24	Lal. 32729	8	8 21.8	+102 02.0	−9.5815	.9658	+0.7296	0.8002	.5812	−.0593	Oregon & California.
24	Lal. 32847	7½	9 31.8	+118 53.3	−9.5828	.9656	+0.7428	0.8083	.5812	−.0570	Oregon & California
24	Lal. 32852	9	9 31.8	+118 52.4	−9.5802	.9661	+0.7303	0.6614	.5818	−.0570	Oregon & California.
24	Lal. 32865	7½	9 45.8	+122 15.2	−9.5819	.9658	+0.7614	0.7427	.5813	−.0558	Oregon & California.
24	Lal. 32886	7½	9 57.8	+125 08.5	−9.5834	.9655	+0.7410	0.8186	.5809	−.0558	Oregon.
25	B.A.C. 6400	7	6 45.8	+ 65 26.4	−9.5922	.9640	+0.7027	0.6781	.5756	−.0071	
25	ν¹ Sagittarii	5	8 15.8	+ 87 01.5	−9.5905	.9643	+0.6233	0.5698	.5760	−.0037	California & Mexico.
25	ν² Sagittarii	5	8 45.8	+ 94 18.7	−9.5892	.9645	+0.6845	0.4931	.5760	−.0026	California & Mexico.
25	B.A.C. 6448	7	9 15.8	+101 36.0	−9.5982	.9629	+0.7461	1.0249	.5736	−.0015	Oregon.
25	Lal. 35217	8	9 21.8	+102 58.0	−9.5977	.9629	+0.6694	0.9959	.5736	−.0015	Oregon.
25	Lal. 35224	8½	9 21.8	+102 55.3	−9.5997	.9626	+0.6265	1.1166	.5732	−.0015	Oregon.
26	Lal. 37433	9	5 41.8	+ 36 44.2	−9.5900	.9644	+0.5180	0.9777	.5649	+.0426	N. E. States.
27	Lal. 39804	8½	6 09.8	+ 30 56.5	−9.5632	.9688	+0.4826	1.1071	.5498	+.0914	N. E. States.
28	Lal. 41606	8½	2 41.8	− 31 48.2	−9.5175	9.9751	−0.1110	+0.9213	.5378	+.1251	Newfoundland.

For facilitating the Computation of such Occultations of Planets and Stars by the Moon *as will be visible in North America during the year* 1851.

1851.	Star's Name.	Mag.	T (h. m.)	H (° ′)	Log sin D	Log cos D	p	q	p'	q'	Where visible.
Nov. 28	Lal. 42038	9	9 51.8	+ 73 14.1	−9.4843	9.9788	+0.8917	+0.2624	.5358	+.1352	California & Mexico.
28	Lal. 42086	8	10 21.8	+ 80 26.0	−9.4869	.9785	+0.8228	0.4502	.5349	+.1359	
28	Lal. 42245	8	12 21.8	+109 30.9	−9.4879	.9784	+0.8507	0.7713	.5328	+.1386	Oregon & California.
29	Lal. 43367	8	2 21.8	− 48 08.0	−9.4358	.9832	−0.3523	0.5601	.5259	+.1562	Newfoundland.
29	Lal. 43371	8½	2 31.8	− 45 39.1	−9.4517	.9819	−0.2926	1.2500	.5243	+.1562	Newfoundland.
29	Lal. 43596	8½	7 06.8	+ 21 33.9	−9.4186	.9845	+0.2874	0.6246	.5234	+.1612	
29	Lal. 43998	8	13 36.8	+116 40.1	−9.3943	.9862	+0.8476	0.7656	.5205	+.1683	California & Mexico.
30	ψ^2 Aquarii	5	13 39.8	+106 55.4	−9.2393	.9934	+0.8730	0.2614	.5117	+.1884	California & Mexico.
30	ψ^3 Aquarii	5	14 11.8	+114 41.0	−9.2574	.9928	+0.8602	0.8366	.5105	+.1892	Oregon & California.
Dec. 1	B.A.C. 8333	7	11 51.8	+ 70 21.7	−9.0679	.9970	+0.7015	0.9727	.5059	+.2011	N. E. States.
5	B. A. C. 845	4	1 09.8	−127 51.0	+9.2169	.9940	−0.8162	0.6005	.5260	+.1923	Newfoundland.
7	B.A.C. 1468	6	12 39.8	+ 16 55.2	+9.5006	.9770	+0.2258	0.3903	.5634	+.1214	
7	B.A.C. 1478	7½	14 15.8	+ 40 23.2	+9.5005	.9771	+0.5266	0.7610	.5656	+.1179	Northern States.
7	*i* Tauri	5½	15 57.8	+ 65 17.2	+9.5033	.9767	+0.8143	+0.8270	.5665	+.1153	Canada.
8	ζ Tauri	3½	9 39.8	− 40 00.5	+9.5552	.9700	−0.5298	−0.0355	.5736	+.0815	Southern States.
9	*d* Geminor	6	18 36.8	+ 77 07.6	+9.5723	.9674	+0.7058	+0.5082	.5880	+.0074	Western States.
10	63 Geminor	6	7 01.8	−105 10.9	+9.5687	.9679	−0.7057	0.6026	.5899	−.0224	
11	39 Cancri	6	13 15.8	− 28 35.9	+9.5448	.9715	−0.3596	0.0855	.5847	−.0932	
11	40 Cancri	6	13 15.8	− 28 37.2	+9.5441	.9716	−0.3800	+0.1228	.5848	−.0932	
14	ν Virginis	4½	23 21.8	+ 79 36.6	+9.1075	.9964	+0.6023	−0.0729	.5564	−.2166	S. W. Territories.
20	B.A.C. 5746	7	18 15.8	− 70 37.4	−9.5399	.9722	−0.6418	+0.6060	.5789	−.1124	
20	B.A.C. 5784	7	20 51.8	− 33 05.6	−9.5435	.9717	−0.6614	0.5022	.5797	−.1072	California & Mexico.
24	Lal. 38572	8½	2 39.8	+ 12 00.2	−9.5807	.9660	+0.4472	0.9899	.5630	+.0482	Newfoundland.
26	Lal. 43204	9	10 51.8	+107 25.9	−9.4330	.9834	+0.7878	0.3026	.5306	+.1572	California & Mexico.
26	Lal. 43367	8	13 11.8	+141 25.4	−9.4358	.9832	+0.8598	0.7860	.5280	+.1600	Oregon.
27	797 Hora 22	8	3 27 8	− 11 44.0	−9.3770	.9873	+0.1338	0.9350	.5205	+.1746	Newfoundland.
27	840 Hora 22	8½	5 03.8	+ 11 45.5	−9.3614	.9882	+0.3545	0.6697	.5202	+.1759	N. E. States.
27	899 Hora 22	8½	6 51.8	+ 38 07.2	−9.3673	.9879	+0.5259	1.1943	.5182	+.1777	Canadas.
27	918 Hora 22	9	7 39.8	+ 49 53.4	−9.3461	.9890	+0.6598	0.6157	.5190	+.1782	
27	956 Hora 22	7	8 51.8	+ 67 28.0	−9.3320	.9897	+0.7766	0.3729	.5188	+.1795	Southern States.
27	B.A.C. 7976	7	9 15.8	+ 73 19.5	−9.3512	.9888	+0.8125	1.0737	.5172	+.1798	Northern States.
27	1047 Hora 22	9	11 27.8	+105 24.4	−9.3151	.9905	+0.8710	0.3140	.5177	+.1815	California & Mexico.
27	1065 Hora 22	9	11 51.8	+111 12.5	−9.3108	.9907	+0.8455	0.2561	.5175	+.1819	California & Mexico.
27	1092 Hora 22	9	12 31.8	+120 56.6	−9.3091	.9908	+0.8770	0.3270	.5172	+.1823	California & Mexico.
28	597 Hora 23	9	6 45.8	+ 26 05.6	−9.2020	.9944	+0.3647	0.9126	.5093	+.1951	
28	684 Hora 23	9	9 51.8	+ 71 37.2	−9.1813	.9949	+0.7423	1.0450	.5083	+.1966	N. W. Territories.
28	738 Hora 23	9	11 33.8	+ 96 27.6	−9.1517	.9956	+0.8085	0.7384	.5084	+.1974	Oregon & California.
29	281 Hora 0	8	9 11.8	+ 51 45.8	−8.8745	.9988	+0.6685	0.8431	.5043	+.2057	
29	366 Hora 0	8	12 39.8	+102 29.7	−8.8048	.9991	+0.8596	0.8511	.5043	+.2064	Oregon & California.
31	B. A. C. 612	7	13 11.8	+ 89 57.1	−8.9667	9.9981	+0.5943	+0.9826	.5123	+.2024	N. W. Territories.

NOTES.

B. A. C.—British Association Catalogue.
Hora.—Weisse's Catalogue.
Lal.—Lalande's Catalogue.
Rumk.—Rumker's Catalogue.

PREDICTION OF OCCULTATIONS.

In the prediction of an occultation for a particular place, the principal objects of determination are, the instant of *immersion*, or of the star's disappearance behind the moon's limb; of *emersion*, or of the star's re-appearance; and the points on the moon's border where these appearances take place.

The calculations, according to the method of the late Professor Bessel, are greatly facilitated by means of the quantities T, H, p, q, p', q', given in the preceding list. Those who may wish to consult Prof. Bessel's original paper on this subject, will find it in Schumacher's *Astronomische Nachrichten*, Vol. VII., page 1; also in the *Berliner Astronomisches Jahrbuch* for 1831, page 257. The process of computation is shown by the following equations:

d = Longitude from Greenwich, of the place, + East, — West.

ϕ = Geographical North Latitude of the place.

ϕ' = Geocentric North Latitude of the place.

r = Earth's radius at the place, or the distance of the observer's position from the earth's centre.

It is unnecessary to calculate ϕ' and r separately, as we have

$$r\sin\phi' = \frac{(1-e^2)\sin\phi}{\sqrt{(1-e^2\sin^2\phi)}} \qquad r\cos\phi' = \frac{\cos\phi}{\sqrt{(1-e^2\sin^2\phi)}}$$

in which e denotes the eccentricity of the earth's meridians.

The logarithms of $\frac{1-e^2}{\sqrt{(1-e^2\sin^2\phi)}} = \log A$, and of $\frac{1}{\sqrt{(1-e^2\sin^2\phi)}} = \log B$, derived from $e = \cdot081697$, according to the latest determination of Prof. Bessel, may be taken from the following table, where the geographical latitude of the place is the argument.

c

ϕ	Log A	Log B
0	9.9971	0.0000
10	9.9971	0.0000
20	9.9973	0.0002
30	9.9975	0.0004
40	9.9977	0.0006
50	9.9979	0.0009
60	9.9982	0.0011
70	9.9984	0.0013

$$r\sin\phi' = A\sin\phi$$
$$r\cos\phi' = B\cos\phi$$

$$a = r\cos\phi'\sin(H+d)$$
$$b = r\cos\phi'\cos(H+d)$$

$$\log\lambda = 9{\cdot}4192$$

$$u = a \qquad\qquad u' = b\lambda$$
$$v = r\sin\phi'\cos D - b\sin D \qquad\qquad v' = a\lambda\sin D$$

$$m\sin M = p - u \qquad\qquad n\sin N = p' - u'$$
$$m\cos M = q - v \qquad\qquad n\cos N = q' - v$$

$$\log k = 9{\cdot}4354$$

$$\cos\psi = \frac{m\sin(M-N)}{k}$$
$$Q = 270^\circ - N \mp \psi$$
$$t = -\frac{m}{n}\cos(M-N) \mp \frac{k\sin\psi}{n}$$

Upper signs for Immersion ; under signs for Emersion.

$$\tan P = \frac{u + tu'}{v + tv'}$$
$$V = Q + P$$

Mean Solar Time of the Star's apparent contact with the moon's limb

$$= T + d + t$$

Angle from *North Point* $= Q$

Angle from *Vertex* $= V$

The angle ψ is to be taken out positive and less than 180°. If $\log m\sin(M-N)$ be greater than log k, cos ψ will evidently be greater than 1, or impossible, and there will be no occultation, except in some rare instances where the moon's limb passes

very close to the star, when log cos ψ will result very near 0. In these cases, a re-calculation should be made according to the method which follows, using

$$t = -\frac{m}{n}\cos(M-N),$$

which may give log $m\sin(M-N)$ less than log k, when the star will be occulted. On the other hand, it may happen that in these cases of very near approach, a first determination may give a cos ψ less than 1, which a re-calculation will show to be impossible. The angle ψ is then to be considered $= 0°$ when $m\sin(M-N)$ is positive, and we shall have $Q = 270°-N$. When $m\sin(M-N)$ is negative, $\psi = 180°$, or $Q = 270°-N+180°$. We shall also have, at the time of nearest approach,

$$\text{star's distance from moon's limb} = 57' \times \big(m\sin(M-N) - {\cdot}2725\big), \text{ nearly,}$$

the error in this computed distance increasing *with* the distance.

By *Angle from North Point*, is to be understood the arc included between the star, when in contact, and the point where the limb is intersected by an arc of a great circle passing from the moon's centre to the North Pole; and by *Angle from Vertex*, the arc between the star at contact, and the point where the limb is intersected by an arc of a great circle passing from the moon's centre to the zenith. These angles are reckoned from the North point and from the vertex, towards the right hand round the circumference of the moon's disc, as seen with an inverting telescope. For *direct* vision, add 180° to the angles given by the equations. It is usual to compute these angles for both phases of an occultation; but for an immersion, they are of no importance, unless when daylight is present or where the star is so small as to be seen with some difficulty. Where several stars of a close group are occulted at nearly the same time, the angles are useful for the purpose of identifying a particular star. For an emersion, one of the angles, at least, is indispensable. With a telescope equatorially mounted and furnished with a position-micrometer, the angle from North point only will be required. The angle from vertex may also be dispensed with where the observer is tolerably familiar with the positions of the more prominent spots on the lunar disc.

The results obtained by the above equations are only approximate, yet the computed times of immersion and emersion will generally be within one or two minutes of the truth. The error increases with the star's distance from the apparent path of the moon's centre, and is greater where the interval of time, t, is large, than where it is small. In some cases, it may amount to several minutes. For an immersion, this error is not of much consequence, but for an emersion, especially of a small star, the time should be determined with greater precision. For this purpose, u' and v' must be computed with

$$H' = H + d + t \times 451'{\cdot}2$$

$$\log\lambda = \frac{2\sin(t \times 451'{\cdot}2)}{t}$$

The following table contains log λ and $t \times 451'{\cdot}2, = \varkappa$, for values of t between 0^h and 2^h:

t	Log λ	$\varkappa$	t	Log λ	$\varkappa$	t	Log λ	$\varkappa$	t	Log λ	$\varkappa$
h.		° ′	h.		° ′	h.		° ′	h.		° ′
0.00	9.4192	0 0.0	0.50	9.4188	3 45.6	1.00	9.4179	7 31.2	1.50	9.4163	11 16.8
0.01	9.4192	0 4.5	0.51	9.4188	3 50.1	1.01	9.4179	7 35.7	1.51	9.4163	11 21.3
0.02	9.4192	0 9.0	0.52	9.4188	3 54.6	1.02	9.4179	7 40.3	1.52	9.4163	11 26.8
0.03	9.4192	0 13.5	0.53	9.4188	3 59.2	1.03	9.4178	7 44.8	1.53	9.4162	11 30.4
0.04	9 4192	0 18.1	0.54	9.4188	4 3.7	1.04	9.4178	7 49.3	1.54	9.4162	11 34.9
0.05	9.4192	0 22.6	0.55	9.4188	4 8.2	1.05	9.4178	7 53.8	1.55	9.4162	11 39.4
0.06	9.4192	0 27.1	0.56	9.4188	4 12.7	1.06	9.4177	7 58.3	1.56	9.4161	11 43.9
0.07	9.4191	0 31.6	0.57	9.4187	4 17.2	1.07	9.4177	8 2.8	1.57	9.4161	11 48.4
0.08	9.4191	0 36.1	0.58	9.4187	4 21.7	1.08	9.4177	8 7.3	1.58	9.4160	11 53.0
0.09	9.4191	0 40.6	0.59	9.4187	4 26.2	1.09	9.4177	8 11.8	1.59	9.4160	11 57.5
0.10	9.4191	0 45.1	0.60	9.4187	4 30.7	1.10	9.4176	8 16.4	1.60	9.4160	12 2.0
0.11	9.4191	0 49.6	0.61	9.4187	4 35.3	1.11	9.4176	8 20.9	1.61	9.4159	12 6.5
0.12	9.4191	0 54.1	0.62	9.4187	4 39.8	1.12	9.4176	8 25.4	1.62	9.4159	12 11.0
0.13	9.4191	0 58.7	0.63	9.4187	4 44.3	1.13	9.4176	8 29.9	1.63	9.4158	12 15.5
0.14	9.4191	1 3.2	0.64	9.4186	4 48.8	1.14	9.4175	8 34.4	1.64	9.4158	12 20.0
0.15	9.4191	1 7.7	0.65	9.4186	4 53.3	1.15	9.4175	8 38.9	1.65	9.4158	12 24.6
0.16	9.4191	1 12.2	0.66	9.4186	4 57.8	1.16	9.4175	8 43.4	1.66	9.4157	12 29.1
0.17	9.4191	1 16.7	0.67	9.4186	5 2.3	1.17	9.4174	8 47.9	1.67	9.4157	12 33.6
0.18	9.4191	1 21.2	0.68	9.4186	5 6.8	1.18	9.4174	8 52.5	1.68	9.4156	12 38.1
0.19	9.4191	1 25.7	0.69	9.4186	5 11.4	1.19	9.4174	8 57.0	1.69	9.4156	12 42.6
0.20	9.4191	1 30.2	0.70	9.4185	5 15.9	1.20	9.4174	9 1.5	1.70	9.4156	12 47.1
0.21	9.4191	1 34.8	0.71	9.4185	5 20.4	1.21	9.4173	9 6.0	1.71	9.4155	12 51.6
0.22	9.4191	1 39.3	0.72	9.4185	5 24.9	1.22	9.4173	9 10.5	1.72	9.4155	12 56.1
0.23	9.4191	1 43.8	0.73	9.4185	5 29.4	1.23	9.4173	9 15.0	1.73	9.4154	13 0.6
0.24	9.4191	1 48.3	0.74	9.4185	5 33.9	1.24	9.4172	9 19.5	1.74	9.4154	13 5.1
0.25	9.4191	1 52.8	0.75	9.4184	5 38.4	1.25	9.4172	9 24.0	1.75	9.4153	13 9.7
0.26	9.4191	1 57.3	0.76	9.4184	5 42.9	1.26	9.4172	9 28.6	1.76	9.4153	13 14.2
0.27	9.4191	2 1.8	0.77	9.4184	5 47.4	1.27	9.4171	9 33.1	1.77	9.4152	13 18.7
0.28	9.4191	2 6.3	0.78	9.4184	5 52.0	1.28	9.4171	9 37.6	1.78	9.4152	13 23.2
0.29	9.4191	2 10.9	0.79	9.4184	5 56.5	1.29	9.4171	9 42.1	1.79	9.4152	13 27.7
0.30	9.4190	2 15.4	0.80	9.4184	6 1.0	1.30	9.4170	9 46.6	1.80	9.4151	13 32.2
0.31	9.4190	2 19.9	0.81	9.4183	6 5.5	1.31	9.4170	9 51.1	1.81	9.4151	13 36.7
0.32	9.4190	2 24.4	0.82	9.4183	6 10.0	1.32	9.4170	9 55.6	1.82	9.4150	13 41.2
0.33	9.4190	2 28.9	0.83	9.4183	6 14.5	1.33	9.4169	10 0.1	1.83	9.4150	13 45.7
0.34	9.4190	2 33.4	0.84	9.4183	6 19.0	1.34	9.4169	10 4.7	1.84	9.4149	13 50.2
0.35	9.4190	2 37.9	0.85	9.4182	6 23.5	1.35	9.4169	10 9.2	1.85	9.4149	13 54.8
0.36	9.4190	2 42.4	0.86	9.4182	6 28.1	1.36	9.4168	10 13.7	1.86	9.4148	13 59.3
0.37	9.4190	2 47.0	0.87	9.4182	6 32.6	1.37	9.4168	10 18.2	1.87	9.4148	14 3.8
0.38	9.4190	2 51.5	0.88	9.4182	6 37.1	1.38	9.4168	10 22.7	1.88	9.4147	14 8.3
0.39	9.4190	2 56.0	0.89	9.4182	6 41.6	1.39	9.4167	10 27.2	1.89	9.4147	14 12.8
0.40	9.4190	3 0.5	0.90	9 4181	6 46.1	1.40	9.4167	10 31.7	1.90	9.4146	14 17.3
0.41	9.4189	3 5.0	0.91	9.4181	6 50.6	1.41	9.4167	10 36.2	1.91	9.4146	14 21.8
0.42	9.4189	3 9.5	0.92	9.4181	6 55.1	1.42	9.4166	10 40.8	1.92	9.4146	14 26.3
0.43	9.4189	3 14.0	0.93	9.4181	6 59.6	1.43	9.4166	10 45.3	1.93	9.4145	14 30.9
0.44	9.4189	3 18.5	0.94	9.4180	7 4.2	1.44	9.4166	10 49.8	1.94	9.4145	14 35.4
0.45	9.4189	3 23.1	0.95	9.4180	7 8.7	1.45	9.4165	10 54.3	1.95	9.4144	14 39.9
0.46	9.4189	3 27.6	0.96	9.4180	7 13.2	1.46	9.4165	10 58.8	1.96	9.4144	14 44.4
0.47	9.4189	3 32.1	0.97	9.4180	7 17.7	1.47	9.4165	11 3.3	1.97	9.4143	14 48.9
0.48	9.4189	3 36.6	0.98	9.4180	7 22.2	1.48	9.4164	11 7.8	1.98	9.4143	14 53.5
0.49	9.4188	3 41.1	0.99	9.4179	7 26.7	1.49	9.4164	11 12.3	1.99	9.4142	14 58.0
0.50	9.4188	3 45.6	1.00	9.4179	7 31.2	1.50	9.4163	11 16.8	2.00	9.4142	15 2.5

With $\varkappa$ and log λ, taken from this table, with t as argument, ($\varkappa$ with the same sign as t,) we have

$$H' = H + d + \varkappa$$

$$u' = r\cos\phi'\lambda\cos H'$$
$$v' = r\cos\phi'\lambda\sin D\sin H'$$

Then, with these values of u' and v', compute N, n, ψ, and t, by means of

$$n\sin N = p' - u'$$
$$n\cos N = q' - v'$$

$$\cos\psi = \frac{m\sin(M-N)}{k}$$

$$t = -\frac{m}{n}\cos(M-N) \mp \frac{k\sin\psi}{n}$$

using the M and m obtained by the first computation, and we shall have the time of contact, $T + d + t$, generally within a few seconds of the truth.

As a check on the accuracy of the work, we might compute

$$u = r\cos\phi'\sin(H + d + t \times 902'{\cdot}4)$$
$$v = r\sin\phi'\cos D - r\cos\phi'\cos(H + d + t \times 902'{\cdot}4)$$

and we should have

$$(p + tp' - u)^2 + (q + tq' - v)^2 = k^2 = 0{\cdot}0743$$

but if $m\sin M$, $m\cos M$, $\log n\sin N$, and $\log n\cos N$, have been correctly computed, we have the following much shorter and more convenient check on the subsequent calculations for the time of contact:

$$(m\sin M + tn\sin N)^2 + (m\cos M + tn\cos N)^2 = k^2 = 0.0743$$

For an example of the practical application of the preceding formulæ, we will make the requisite calculations for an occultation of ξ^1 Libræ on the 20th of February, 1851, as it will appear at Halifax, Nova Scotia; in north latitude $44°\ 39'.3 = \phi$, and longitude from Washington $13°\ 27'.0 = 0^h\ 53^m.8 = d$. We have the given star and date on page 9; and taking out the corresponding quantities T, H, etc., we have the data for computation, as follows:—

February 20*th*, 1851. ξ^1 *Libræ*.

$T =$	$12^h\ 51^m.8$	$H =$	$-\ 58°4'.4$	$p =$	$-\ 0.5744$
$d =$	$+\ 0\ 53.8$	$d =$	$+\ 13\ 27.0$	$q =$	$+\ 0.8880$
$T+d =$	$13\ 45.6$	$H+d =$	$-\ 44\ 37.4$	$p' =$	$+\ 0.5546$
$\log\sin D =$	$-\ 9.2917$	$\log\cos D =$	$+\ 9.9915$	$q' =$	$-\ 0.1824$

Calculation.

(Table, page 18, Arg. ϕ)	$\log A$		9.9978
	$\log\sin\phi$	+	9.8469
$\log A\sin\phi =$	$\log r\sin\phi'$	+	9.8447
	$\log\cos D$	+	9.9915
	$\log r\sin\phi'\cos D$	+	9.8362
(Table, page 18, Arg. ϕ)	$\log B$		0.0007
	$\log\cos\phi$	+	9.8521
	$\log r\cos\phi'$	+	9.8528
	$\log\sin(H+d)$	−	9.8466
$\log r\cos\phi'\sin(H+d) =$	$\log u = \log a$	−	9.6994
	$\log\cos(H+d)$	+	9.8523
$\log r\cos\phi'\cos(H+d) =$	$\log b$	+	9.7051
	$\log\lambda$		9.4192
	$\log a\lambda$	−	9.1186
	$\log\sin D$	−	9.2917
	$\log b\sin D$	−	8.9968
$\log a\lambda\sin D =$	$\log v'$	+	8.4103
$\log b\lambda =$	$\log u'$	+	9.1243
	$r\sin\phi\cos D$	+	.6858
	$b\sin D$	−	.0993
$r\sin\phi\cos D - b\sin D =$	v	+	.7851
	q	+	.8880
$q - v =$	$m\cos M$	+	.1029
$a =$	u	−	.5005
	p	−	.5744
$p - u =$	$m\sin M$	−	.0739
	v'	+	.0257
	q'	−	.1824
$q' - v' =$	$n\cos N$	−	.2081
	u'	+	.1331
	p'	+	.5546
$p' - u' =$	$n\sin N$	+	.4215
	$\log m\sin M$	−	8.8686
	$\log m\cos M$	+	9.0124
	$\log\tan M$	−	9.8562
	$\log\cos M$	+	9.9097
	$\log m$	+	9.1027
	$\log n\sin N$	+	9.6248
	$\log n\cos N$	−	9.3183
	$\log\tan N$	−	0.3065
	$\log\sin N$	+	9.9526
	$\log n$	+	9.6722
	$-\log\frac{m}{n}$	−	9.4305

	M		324°19′.0
	N		116 16.7
	$M-N$		208 02.3
			270 00.0
	$270° - N$		153 43.3
	ψ		102 37.2
For Immersion, $270° - N - \psi =$	Q		51 06.1
	$\log\sin(M-N)$	−	9.6721
	$\log m$	+	9.1027
	$\log m\sin(M-N)$	−	8.7748
	$\log k$		9.4354
$\log\frac{m\sin(M-N)}{k} =$	$\log\cos\psi$	−	9.3394
	$\log\sin\psi$	+	9.9894
	$\log k\sin\psi$	+	9.4248
	$\log n$	+	9.6722
$\log\frac{k\sin\psi}{n} =$	$\log(1)$	+	9.7526
	$\log\cos(M-N)$	−	9.9458
	$-\log\frac{m}{n}$	−	9.4305
$-\log\frac{m}{n}\cos(M-N) =$	$\log(2)$	+	9.3763
	(2)	+	.2379
	(1)	+	.5657
For Immersion, $(2)-(1) =$	t_1	−	.3278
For Emersion, $(2)+(1) =$	t_2	+	.8036
$\log t_1$	$\log t$	−	9.5156
	$\log u'$	+	9.1243
	$\log tu'$	−	8.6399
	$\log v'$	+	8.4103
	$\log tv'$	−	7.9259
	tv'	−	.0084
	v	+	.7851
	$v + tv'$	+	.7767
	tu'	−	.0436
	u	−	.5005
	$u + tu'$	−	.5441
	$\log(u+tu')$	−	9.7357
	$\log(v+tv')$	+	9.8903
$\log\frac{u+tu'}{v+tv'} =$	$\log\tan P$	−	9.8454
	$T+d$		$13^h\ 45^m.6$
(Reduced to hours and minutes)	t_1		− 0 19.7

IMMERSION: *Halifax Mean Time* =	$T+d+t_1$	13 25.9
	P	−35° 00′.7
Immersion *Angle from North Point* =	Q	51 06.1
Immersion *Angle from Vertex* = $Q+P$ =	V	16 05.4
(Reduced)	t_2	+ $0^h\ 48^m.2$
EMERSION; *Halifax Mean Time* =	$T+d+t_2$	14 33.8

Calculation for a more accurate determination of the Time, etc., of Emersion.

	$H+d$	$-44°37'.4$
(Table, page 20, Arg. t_2)	$\varkappa$	$+6\ \ 2.6$
$H+d+\varkappa=$	H'	$-38\ 34.8$
	$\log r\cos\phi'$	$+9.8528$
(Table, page 20, Arg. t_2)	$\log\lambda$	9.4184
	$\log\cos H'$	$+9.8930$
$\log r\cos\phi'\lambda\cos H'=$	$\log u'$	$+9.1642$
	$\log r\cos\phi'\lambda$	$+9.2712$
	$\log\sin D$	-9.2917
	$\log\sin H'$	-9.7949
$\log r\cos\phi'\lambda\sin D\sin H'=$	$\log v'$	$+8.3578$
	v'	$+\ .0228$
	q'	$-\ .1824$
$q'-v'=$	$n\cos N$	$-\ .2052$
	u'	$+\ .1460$
	p'	$+\ .5546$
$p'-u'=$	$n\sin N$	$+\ .4086$
	$\log n\sin N$	$+9.6113$
	$\log n\cos N$	-9.3122
	$\log\tan N$	-0.2991
	$\log\sin N$	$+9.9512$
	$\log n$	$+9.6601$
(From first determination)	$\log m$	$+9.1027$
	$-\log\frac{m}{n}$	-9.4426
	$\log\cos(M-N)$	-9.9473
	$\log\sin(M-N)$	-9.6666
	$\log m\sin(M-N)$	-8.7693
	$\log k$	9.4354
$\log\dfrac{m\sin(M-N)}{k}=$	$\log\cos\psi$	-9.3339
	$\log\sin\psi$	$+9.9897$
	$\log k\sin\psi$	$+9.4251$
$\log\dfrac{k\sin\psi}{n}=$	$\log(1)$	$+9.7650$
$-\log\frac{m}{n}\cos(M-N)=$	$\log(2)$	$+9.3899$

(From first determination)	M	$324°19'.0$
	N	$116\ 40.0$
	$M-N$	$207\ 39.0$
		$270\ 00.0$
	$270°-N$	$154\ 20.0$
	ψ	$102\ 27.5$
$270°-N+\psi=$	Q	$256\ 47.5$
	(2)	$+\ .2454$
	(1)	$+\ .5821$
$(2)+(1)=$	t	$+\ .8275$
	$\log t$	$+9.9178$
	$\log n\sin N$	$+9.6113$
	$\log tn\sin N$	$+9.5291$
	$\log n\cos N$	-9.3122
	$\log tn\cos N$	-9.2300
	$tn\cos N$	$-\ .1698$
(From first determination)	$m\cos M$	$+\ .1029$
$m\cos M+tn\cos N=$	(3)	$.0669$
	$tn\sin N$	$+\ .3382$
(From first determination)	$m\sin M$	$-\ .0739$
$m\sin M+tn\sin N=$	(4)	$.2643$
	$(4)^2$	$.0698$
	$(3)^2$	$.0045$
$(4)^2+(3)^2=k^2=0.0743$	Check	$.0743$
	$\log u'$	$+9.1642$
	$\log tu'$	$+9.0820$
	$\log v'$	$+8.3578$
	$\log tv'$	$+8.2756$
	tv'	$+\ .0189$
(From first determination)	v	$+\ .7851$
	$v+tv'$	$+\ .8040$
	tu'	$+\ .1208$
(From first determination)	u	$-\ .5005$
	$u+tu'$	$-\ .3797$
	$\log(u+tu')$	-9.5794
	$\log(v+tv')$	$+9.9053$
$\log\dfrac{u+tu'}{v+tv'}=$	$\log\tan P$	-9.6741
		h. m.
	$T+d$	$13\ 45.6$
(Reduced)	t	$+0\ 49.7$
EMERSION: *Halifax Mean Time* = - - - - - - - - - -	$T+d+t$	$14\ 35.3$
	P	$-25°16'.5$
Emersion *Angle from North Point* = - - - - - - - - - - - -	Q	$256\ 47.5$
Emersion *Angle from Vertex* = $Q+P$ = - - - - - - - - - -	V	$231\ 31.0$

This last determination of the time of emersion is probably true to the nearest tenth of a minute. The angles Q and V are also determined with corresponding precision; but for these, the nearest degree is sufficient for the purpose of making an observation.

Visible at Washington, D. C., during the year 1851.

1851.	Star's Name.	Magnitude.	IMMERSION.				EMERSION.			
			Sidereal Time.	Mean Time.	Angle from N. Point.	Angle from Vertex.	Sidereal Time	Mean Time.	Angle from N. Point.	Angle from Vertex.
			h. m.	h. m.			h. m.	h. m.		
January 7	B. A. C. 8154	7	23 55	4 47	74°	84°	0 55	5 47	347°	11°
11	ξ^2 Ceti	4	22 49	3 26	132	84	0 02	4 39	284	244
11	B. A. C. 845*	4	9 26	14 01	118	168	10 17	14 52	269	316
13	63 Tauri	6	5 01	9 29	148	171	6 03	10 31	245	286
13	B. A. C. 1351	6½	4 47	9 15	114	129	6 09	10 37	279	321
14	B. A. C. 1625	7	1 38	6 02	60	6	2 24	6 48	334	283
15	16 Geminor	6	6 55	11 15	155	176	7 31	11 51	209	245
15	ν Geminor	4	7 08	11 28	83	109	8 25	12 44	276	325
16	61 Geminor	7	4 16	8 32	172	117	4 30	8 46	194	141
17	θ Cancri	5½	4 19	8 31	28	333	4 53	9 05	325	271
23	B. A. C. 4794	7	14 31	18 19	27	29	15 40	19 27	278	297
26	29 Ophiuchi	6	13 04	16 40	161	119	Star 2'.5 south of ☽'s limb.			
29	ξ^2 Sagittarii	4	20 56	0 22	186	212	Star 0'.3 south of ☽'s limb.			
Feb'ry 6	322 Hora 1	7	3 10	6 04	209	241	Star 1'.7 south of ☽'s limb.			
7	158 Hora 2	7	6 01	8 50	161	209	6 46	9 36	240	292
11	χ^2 Orionis	6	6 03	8 37	79	89	7 22	9 56	294	335
11	χ^3 Orionis	5	10 40	13 13	58	113	11 32	14 05	298	352
11	χ^4 Orionis	5	11 16	13 49	178	232	Star 2'.7 south of ☽'s limb.			
14	B. A. C. 3044	7	3 03	5 25	69	16	3 56	6 19	282	228
14	68 Cancri	7	4 58	7 20	80	26	6 04	8 26	265	214
20	ξ^1 Libræ	6	10 34	12 32	13	327	11 16	13 14	295	255
25	B. A. C. 6641	7	15 40	17 17	59	20	16 53	18 30	292	263
March 4	398 Hora 0‡	7½	5 30	6 42	100	150	6 30	7 41	305	356
6	1031 Hora 1	7	7 06	8 09	118	169	8 06	9 10	279	330
7	B. A. C. 845	4	0 51	1 51	133	98	2 13	3 14	285	276
9	Rumker 1246	7	9 42	10 33	65	119	10 33	11 24	306	359
11	ν Geminor	4	5 38	6 22	48	24	6 37	7 20	320	330
12	B. A. C. 2499	7	10 02	10 41	149	201	10 27	11 06	189	243
15	B. A. C. 3662	7½	10 22	10 49	82	77	11 34	12 02	226	249
16	B. A. C. 3940	7	8 13	8 37	60	14	9 21	9 45	252	215
16	B. A. C. 3947	7	8 33	8 56	107	63	9 25	9 49	204	167
18	80 Virginis	6	11 58	12 13	19	355	12 55	13 10	280	271
23	14 Sagittarii	6	15 38	15 33	348	318	Star 4'.2 north of ☽'s limb.			
24	o Sagittarii*	4½	14 09	14 00	352	304	Star 3'.9 north of ☽'s limb.			
28	δ Capricorni	3½	21 53	21 31	19	22	Star 3'.5 north of ☽'s limb.			
April 5	Rumker 1167	7	8 29	7 34	70	124	9 27	8 32	307	1
5	63 Tauri	6	8 53	7 58	60	114	9 43	8 48	316	10
5	Lal. 8249	7½	9 22	8 27	123	177	10 17	9 22	251	304
6	Lal. 10035	7½	11 20	10 21	28	81	11 45	10 46	334	25
8	ζ Geminor	4	2 56	1 52	97	41	4 10	3 05	275	222
9	d^1 Cancri	6	14 19	13 07	346	38	Star 1'.0 north of ☽'s limb.			
11	B. A. C. 3518	7½	12 30	11 11	110	153	13 19	11 59	200	249
12	B. A. C. 3837	6½	11 19	9 56	67	72	12 35	11 12	236	266
13	B. A. C. 4116	7	13 46	12 19	38	67	14 53	13 26	263	304
24	39 Aquarii	7	18 33	16 21	166	126	19 13	17 02	225	190
May 4	χ^4 Orionis	5	12 03	9 14	27	80	12 29	9 40	329	19
5	ζ Geminor	4	13 35	9 41	72	127	14 28	10 34	272	323
6	Lal. 15595	7	11 26	8 29	90	144	12 30	9 32	242	298
6	Lal. 15646	6½	12 05	9 07	90	146	13 05	10 07	242	297
7	δ Cancri	4½	3 14	0 14	41	347	3 58	0 58	312	256
7	68 Cancri	7	13 12	10 11	352	47	13 24	10 22	330	25
7	B. A. C. 3103	7½	14 41	11 39	97	150	15 30	12 28	229	280
10	B. A. C. 3996	6	11 30	8 17	84	80	12 41	9 28	215	235
12	B. A. C. 4593	7	17 54	14 32	71	118	18 56	15 34	246	295
12	n Virginis‡	7	18 30	15 08	42	91	19 23	16 01	278	328

Visible at Washington, D. C., during the year 1851.

1851.		Star's Name.	Magnitude.	IMMERSION.				EMERSION.			
				Sidereal Time.	Mean Time.	Angle from N. Point.	Angle from Vertex.	Sidereal Time	Mean Time.	Angle from N. Point.	Angle from Vertex.
				h. m.	h. m.			h. m.	h. m.		
May	15	χ Ophiuchi	5	14 12	10 39	52°	25°	15 30	11 56	263°	252°
June	1	Lal. 12914	7	12 48	8 08	64	117	13 37	8 57	285	333
	1	Lal. 12933	7	12 55	8 15	103	155	13 44	9 04	246	294
	2	Lal. 15007	7	12 40	7 56	123	178	13 21	8 37	214	267
	2	79 Geminor	7	13 00	8 17	106	160	13 49	9 06	231	283
	3	δ Cancri	4½	13 05	8 17	39	95	13 53	9 06	287	341
	3	B. A. C. 2990‡	7	15 27	10 39	96	146	16 12	11 24	235	281
	5	B. A. C. 3662	7½	14 30	9 35	9	60	15 05	10 09	302	354
	6	B. A. C. 3947	7	14 35	9 35	85	130	15 36	10 36	220	270
	12	B. A. C. 5700	6½	12 49	7 26	96	53	13 51	8 28	223	188
	12	B. A. C. 5784*	7	21 54	16 30	357	45	Star 2′.2 north of ☽'s limb.			
	14	31 Sagittarii	6	15 10	9 39	139	100	15 51	10 20	204	171
	17	γ Capricorni	4	22 55	17 10	147	165	0 05	18 21	263	294
July	1	B. A. C. 3209	7	14 43	8 05	161	215	Star 0′.6 south of ☽'s limb.			
	7	ξ¹ Libræ	6	15 27	8 25	124	135	16 07	9 05	182	201
	8	η Libræ	4½	13 01	5 55	66	33	14 19	7 14	241	223
	8	θ Libræ‡	4½	19 45	12 39	24	67	20 25	13 19	312	359
	12	50 Sagittarii	6	15 28	8 06	119	78	16 32	9 10	231	199
	20	B. A. C. 612	7	0 49	16 54	112	91	2 15	18 21	312	321
	21	B. A. C. 845	4	23 31	15 33	164	117	0 26	16 28	255	215
	23	63 Tauri	6	21 41	13 35	140	90	22 27	14 22	258	205
	23	B. A. C. 1351	6½	21 33	13 28	106	56	22 28	14 22	291	238
August	5	χ Ophiuchi	5	16 34	7 38	68	71	18 00	9 04	258	280
	9	B. A. C. 6889	6	17 37	8 25	69	41	18 58	9 46	300	286
	10	20 Capricorni	6	20 03	10 47	132	121	21 26	12 10	260	268
	13	ψ³ Aquarii†	5	17 33	8 05	87	36	18 35	9 08	308	260
	17	ξ² Ceti	4	0 08	14 23	79	40	1 11	15 26	343	319
	21	χ¹ Orionis	5	23 34	13 34	108	56	0 31	14 31	279	224
	24	B. A. C. 3058*	7	1 19	15 07	176	130	Star 2′.2 south of ☽'s limb.			
	31	91 Hora 15	7	17 34	6 56	355	27	17 55	7 16	324	359
Sept.	7	γ Capricorni	4	1 05	13 58	120	160	2 13	15 06	286	333
	8	B. A. C. 7835‡	6½	3 03	15 52	166	213	3 43	16 31	242	292
	9	ψ¹ Aquarii	5½	3 12	15 57	177	222	3 45	16 30	236	284
	9	ψ² Aquarii‡	5½	3 55	16 39	92	140	4 52	17 37	318	9
	18	15 Geminor	6	23 27	11 37	69	20	0 14	12 24	310	258
	18	B. A. C. 2091	7	0 04	12 14	54	2	0 43	12 53	327	272
	20	B. A. C. 2854	6½	2 00	14 01	28	337	2 27	14 28	329	275
	20	B. A. C. 2899	7	4 21	16 22	114	59	5 22	17 23	237	183
	21	8 Leonis	6½	4 20	16 17	171	117	Star 3′.2 south of ☽'s limb.			
	28	θ Libræ*	4½	21 17	8 48	98	149	22 11	9 42	242	293
	30	58 Ophiuchi	5	19 33	6 57	101	126	20 50	8 14	254	291
Oct.	6	74 Aquarii	6	20 47	7 47	138	111	22 12	9 11	275	266
	7	B. A. C. 8274	6½	4 16	15 10	95	143	5 16	16 10	316	7
	11	B. A. C. 845	4	0 48	11 27	31	356	Star 2′.0 north of ☽'s limb.			
	13	δ² Tauri	4½	0 46	11 17	119	66	2 02	12 33	288	242
	18	80 Cancri	6½	4 21	14 32	173	118	Star 0′.2 south of ☽'s limb.			
	26	Lal. 29696	7	20 10	5 52	28	71	20 51	6 32	313	0
Nov.	1	B. A. C. 7601	7	20 49	6 06	84	71	22 10	7 27	322	329
	5	29 Ceti	6½	6 24	15 24	193	244	6 35	15 35	213	264
	9	δ¹ Tauri‡	4	10 27	19 11	86	138	11 21	20 05	288	336
	12	d Geminor	6	0 50	9 24	136	82	1 38	10 11	242	187
	15	26 Leonis	7	8 06	16 27	68	29	9 28	17 48	249	239
	25	B. A. C. 6400‡	7	22 30	6 13	102	144	23 37	7 20	273	321
Dec.	7	B. A. C. 1468	6	5 01	11 55	100	113	6 27	13 21	293	336
	10	63 Geminor†	6	23 43	6 27	106	61	0 39	7 23	263	212

Visible at Washington, D. C., during the year 1851.

1851.		Star's Name.	Magnitude.	IMMERSION.				EMERSION.			
				Sidereal Time.	Mean Time.	Angle from N. Point.	Angle from Vertex.	Sidereal Time	Mean Time.	Angle from N. Point.	Angle from Vertex.
				h. m.	h. m.			h. m.	h. m.		
Dec.	11	39 Cancri	6	6 16	12 54	151°	101°	6 44	13 22	192°	147°
	11	40 Cancri	6	6 10	12 49	136	85	6 57	13 35	207	164
	20	B. A. C. 5746†	7	11 31	17 33	78	28	12 31	18 34	243	198

* Whole occultation below the horizon of Washington.

† Immersion below the horizon of Washington

‡ Emersion below the horizon of Washington.

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PHILADELPHIA.

CONTENTS.

APPENDIX.